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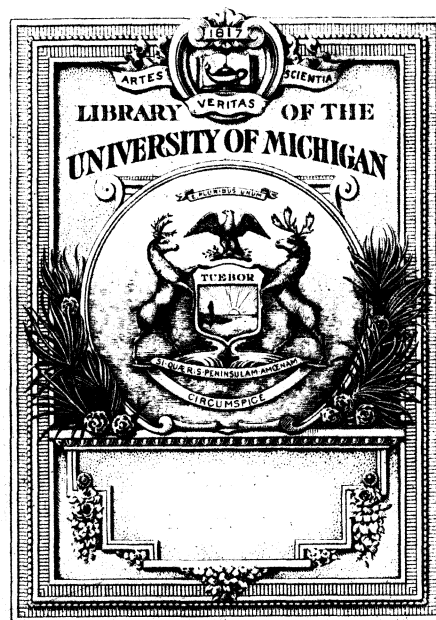
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THE PHILIPPINE JOURNAL OF SCIENCE

VOLUME 45

MAY TO AUGUST, 1931

WITH 106 PLATES AND 39 TEXT FIGURES



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1931

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THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 45

MAY, 1931

No. 1

FISHING METHODS IN LAGUNA DE BAY

By VICENTE C. ALDABA

Of the Bureau of Science, Manila

TWELVE PLATES AND NINE TEXT FIGURES

INTRODUCTION

Laguna de Bay is the largest and probably the most important fishing lake in the Philippines. It has an area of 930.7 square kilometers,¹ excluding Talim Island. It is located in the center of southern Luzon and is only a short distance from the City of Manila. It rises more than 2 meters above sea level, receives drainage from numerous small streams on all sides, and in turn is drained by the Pasig River into Manila Bay. The lake is uniformly shallow, having a practically level floor, which gradually rises to slightly inclined shores around the major portion of the coast.

The littoral districts are well populated and there are good roads all around the lake, except around the Jalajala Peninsula from Pililla to Mabitac, and in Talim Island. The railroad passes near the western and southern shores.

The greater portion of the fish caught is sold in the markets of bordering towns. However, a considerable quantity is taken fresh to the City of Manila, and to San Pablo for consumption by the people inhabiting the interior towns of Laguna Province and the towns of Tayabas near-by.

¹ Pratt, W. E., Philip. Journ. Sci. § A 11 (1916) 223-226.

THE KINDS OF FISHES CAUGHT IN LAGUNA DE BAY

There are only a few species of fishes caught in considerable quantities in Laguna de Bay. *Dalag*, *Ophicephalus striatus* Bloch; *kanduli*, *Arius* spp.; and several species of gobies are the most important. *Hito*, *Clarias batrachus* (Bloch); climbing perch, *Anabas testudineus* (Bloch); *ayoñgin*, *Therapon argenteus* (Cuvier and Valenciennes); *talilong*, *Mugil* spp.; *palos*, *Anguilla* spp.; *buanbuan*, *Megalops cyprinoides* (Broussonet); and *tagan*, *Pristis microdon* Latham, are also caught in considerable quantities. Shrimps (Palæmonidæ and Atyidæ), being of considerable value both as human food and as fertilizer to the betel vine, which is extensively cultivated around the lake, should also be included in the list. In this connection mention should be made of the gathering of various kinds of shells to supply certain feed requirements for the extensive duck industry along the coast of the lake.

METHODS OF CATCHING DALAG

The importance of dalag to the people living along the coast of Laguna de Bay is indicated by the fact that there are more different ways to catch it than are used for all other kinds of fishes in the lake. Then, too, most of the apparatus used in capturing dalag is inexpensive, which probably accounts for the greater number of people engaged in fishing for this particular species.

With bare hands.—To capture dalag with the bare hands is not easy. Of all the common species in Laguna de Bay this fish is probably the most shy and energetic. It can jump a long distance and moves through the water very swiftly. Even out of water a dalag of some size is hard to handle. It requires, therefore, a good deal of experience and skill to capture the dalag with the bare hands while it is in the water. Usually only the small ones are caught in this way.

In rice paddies that have been puddled, the dalag is more readily caught because it cannot move so easily through the muddy water.

In certain places in Laguna de Bay during the dry season when the water in the lake has practically reached its lowest level, dalag in large numbers are left imprisoned among grasses and water hyacinths. During this time people catch dalag in quantities with their bare hands. This is especially true

along the grassy shore line of the eastern lobe of Laguna de Bay.

Salacab.—All around Laguna de Bay the *salacab* (Plate 1, fig. 1) is certainly the commonest fishing apparatus. One or more of these traps may be seen under most houses in all the fishing villages, either hanging or standing on the ground. It is handy for any member of the family to take to any creek or to the lake to catch fish with for the next meal. Its main importance, however, lies in the fact that it supplies the market with considerable quantities of dalag. Because in water where this trap is successfully operated dalag is the commonest inhabitant, this fish makes up the major portion of the fishermen's catch.

The size of the *salacab* most commonly seen around the lake is about one-half meter in diameter at the bottom opening, and a little less than a meter in height. The upper opening is narrower, being just large enough for a hand or a foot² to be inserted in order to take out the catch. It is made of bamboo splints about one centimeter in width, tied at regular intervals with split rattan to two or more bamboo, wooden, or iron hoops.

In operating this trap the fisherman holds it with one hand at the upper opening and drives it into the water vertically with sufficient force to embed the lower part in the mud. This performance is repeated until a fish is caught. The fisherman is instantly aware of his catch as the fish, in its attempt to escape, bumps violently against the sides of the trap. A hand is then inserted through the top opening to take the fish out.

Fishing with the salacab on a carabao.—This is an interesting method of catching dalag. The dalag is not disturbed or frightened by a carabao so the fisherman, taking advantage of this fact, mounts a carabao and with a *salacab* in hand rides around looking for dalag. A shallow place with grass or other kinds of growth is chosen for this kind of fishing. When the exact location of a dalag is determined by the movement of the water and plant growth or by the appearance of its head on the surface of the water, the fisherman promptly dismounts from the carabao and covers the dalag with the *salacab*. Sometimes the fisherman uses a baited hook to tempt the dalag to show its head. A dalag nest is usually sought for.

² The use of the foot will be explained in discussing the methods of capturing kandull.

Sucob.—This particular net trap is probably a development of the *salacab*. At least practically the same idea is involved in both. But the *sucob* consists of a net cone mounted on a strong conical bamboo or wooden frame (Plate 1, fig. 2). The lower rim of the frame is often made of a thin iron strip. The frame is about 3.5 meters in diameter at the base and about 1.5 meters in altitude. The net is about 2.5 meters high with a mesh of about 4.2 centimeters stretched. It is usually handled by three men, and operated in water 2 meters deep.

In going to the fishing ground fishermen carry this trap in a banca. One man sitting on the prow carefully surveys the water ahead of him, alert for any movement that may indicate the presence of a dalag school, and if he detects such a school he signals to the two men at the stern who row the banca noiselessly. The watcher throws small stones into the precise spot to be covered by the *sucob*, the idea being to make the fish stay at the bottom so they can be approached without being scared away. As the banca nears the place indicated, the watcher puts the *sucob* which is behind him in a ready position, promptly dropping it into the water as soon as the spot is reached, at the same time putting his weight on the trap by sitting on the vertex of the conical frame. The other two men immediately jump into the water and work with their feet, diving at times, to put the lower rim of the net into the mud so that there can be no possible escape for the fish. The man resting on top of the cone frame unties the upper end of the net and allows the other men to get inside the trap to take the grasses and other rubbish out. When this is done they come out of the net before catching the imprisoned fish. They do this by feeling carefully for the fish which, in trying to escape, bulges out the net, thus creating a sort of temporary bag in which it is held. The man gets hold of it, diving if necessary, and takes it out of the net through the top opening.

Dala (casting net).—Along the western coast of Talim Island this net is employed in catching dalag. Here the bottom of the lake is sandy and there is no grass to interfere with the sinking of the rim of the *dala*, so that with adequate weights the net can be made to sink fast enough to capture the dalag. The dalag is caught in practically the same way as with the *sucob*. Usually only two men are needed in fishing for dalag with this gear, one rowing the boat, and the other locating dalag schools and casting the net.

Panteng pukot.—This is a net varying in length from 20 to 100 meters and wide enough to operate in water breast deep. It carries floats but not weights, the bottom line sinking of its own accord. The mesh is of such dimensions that only fish of considerable size are caught. This is used in rivers with very slow current.

The fisherman in spreading the net starts from one bank of the river, crosses it, and then moves parallel to and close to the other bank. The place chosen is a clean portion of a river but always with a more shady and bushy place a little above it. The shaded portion is known to be the hiding place of the fish. To drive the fish into the net, one or more companions of the fisherman beat the water in the shaded place. To enclose the fish within the net, the two ends are brought together by first dragging slowly across the river the portion of the net parallel to the bank until this end meets the other. Further manipulation of the net finally makes it assume the shape of a flattened circle with two distinct parallel sides, the distance between which gives only enough room for the fisherman to walk back and forth with his hands feeling the outside of the net. The fish, being scared by the movement of the man, tries to escape by rushing outward. Thus a temporary pocket is created in the net in which the fish is imprisoned. The fisherman gets hold of the fish while it is in this position.

This apparatus may catch more hito than dalag when there happen to be more of the former kind.

Pukot dalag.—This is also known as *pukot gilid* and *barimbao*. This is a net 200 to 300 meters in length and operated near the shore of the lake in water about 2 meters deep. It carries floats but usually no weights, the lower line, which is of heavy rope, being heavy enough to keep the net close to the bottom. It has a bag, the upper part of the opening of which is held high above the water by stakes, while the lower portion is kept under water as the net is dragged along. When fish are secured in the net the entire opening of the bag is held high above the water. The catch is taken out of the bag with the help of dip nets. The mesh of the bag is about 2 centimeters and that of the dragnet varies from about 3 centimeters near the bag to about 5 centimeters towards the end.

The details of the operation may be seen in fig. 1. As shown in this figure, the banca carrying the men assumes three positions, each of which enables them to pull the net in a line tan-

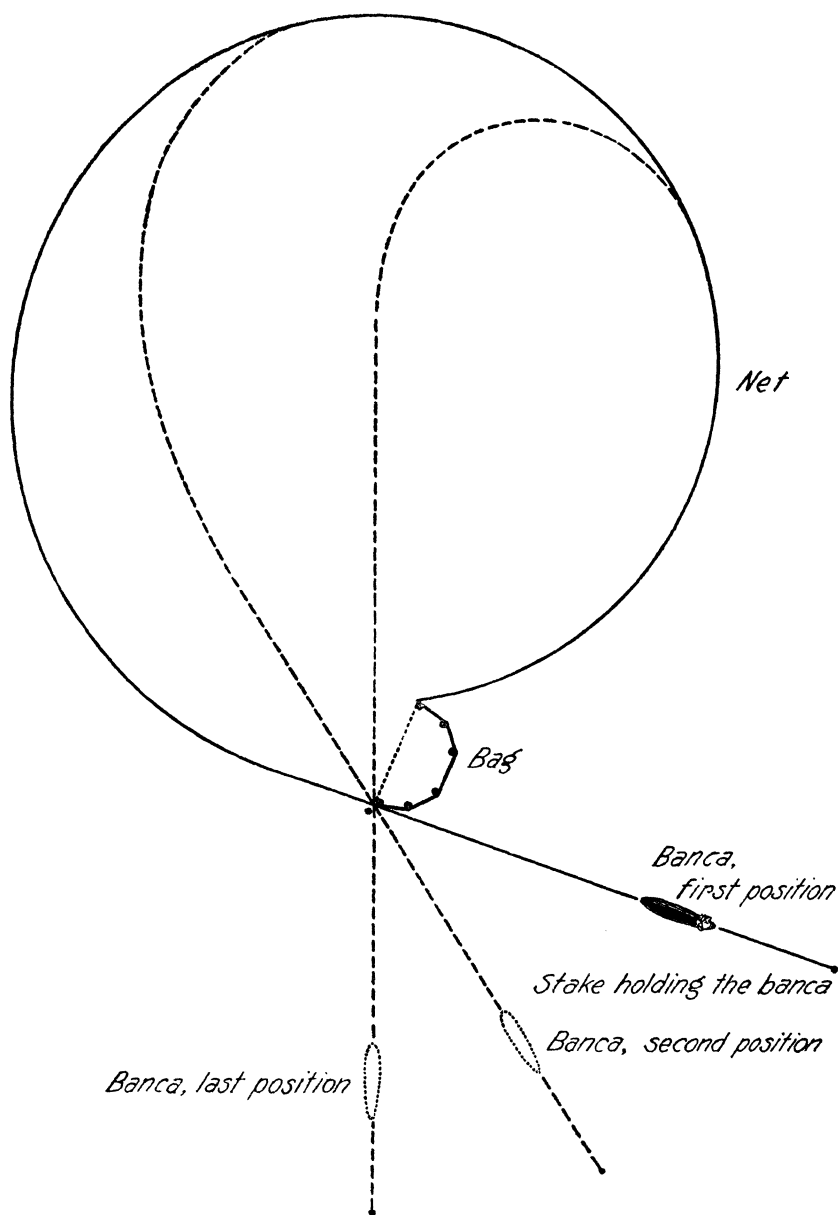


FIG. 1. Diagram to show the positions of the banca, which carries the men, at different stages of pulling the net of a pukot dalag.

gential to the circle formed by the apparatus. These changes in position are necessary to make the work as light as possible.

The catch consists mainly of dalag but some kanduli and gobies are also captured. It should be mentioned in this connection

that a very similar apparatus, the *pukot laot*, operated in deeper parts of Laguna de Bay, catches mainly kanduli and some gobies but practically no dalag, thus showing that the distribution of the dalag is limited to the water near the shore.

Salapang.—This is a spear with barbed iron points varying from three to seven in number. The shaft is from 2 to 3 meters long and is usually made of bamboo. It is used in the night with a strong light by a fisherman who, while watching for the fish, stands in a banca that is rowed by another. This is a common method of catching various kinds of fishes in different places, but in Laguna de Bay it is used mainly for catching dalag.

Alcabus or arcabuz.—This ancient weapon is still effective in catching dalag. It is a strong bamboo bow mounted transversely on a wooden stock (Plate 2, fig. 1). There is a movable pin which holds the string and a trigger to release it. To guide the arrow, which carries several barbed iron wires forming the head, there is a groove in which it rests snugly before the fisherman releases the string to shoot a dalag.

There are two kinds of arrows used. One carries a detachable head; in the other the head is rigidly fixed to the shaft. In the first case there is a string which holds the head to the shaft when the former is detached from the latter, a thing which happens when a dalag is hit and tries to escape.

The effectiveness of this old weapon rests solely on the peculiar habit of the dalag of coming slowly to the surface of the water at certain intervals, at the same time releasing bubbles of air. It is while the dalag is leisurely coming to the surface that the fisherman takes his aim and releases the trigger.

A fisherman usually chooses his position after a dalag nest has been located.

Patucba.—This consists of a small bamboo rod carrying a line with a baited hook and standing in shallow water. The bait is a living frog. A fisherman may have as many as fifty or more of these rods at a time in a place.

Pamitin.—At certain seasons of the year frog baits are hard to obtain and command a high price in the market varying from 20 to 50 centavos a hundred. Many fishermen resort to using a snail, or *cohol*, *Ampullaria* sp., without the shell. In this case the water where the baited hook is placed is made turbid by stirring it with the hands or feet. The object is to prevent the bait from being nibbled away by smaller fishes, such as

baṅgayṅgay, *Ophiocara aporos* Bleeker. Hooks baited and set in the way described are called *pamitin* in the eastern part of the Laguna de Bay region, where they are common.

Palaway.—This is a long line and many short ones; the main line is held tautly above the water by means of bamboo stakes standing at regular intervals. The short lines carrying the hooks are about 0.5 meter long and are attached to the main line at intervals of about 2.5 meters. The bait consists of a living frog held just touching the surface of the water.

This fishing apparatus is known sometimes as *patucba*, but it is generally referred to as *kitang* although *palaway* is the specific term.

Galay consists of a hook of considerable size baited with a frog and suspended by a line about a meter long from a rod 3 or 4 meters in length. A man operates only one galay at a time and he usually fishes for a nesting dalag. Sometimes a man with this apparatus fishes from a banca, usually along a grassy shore line.

Rattan bocatot.—This fishing apparatus is simply a deep pocket made of split rattan in the fashion of a net (fig. 2). The mesh varies from about 2 centimeters square at the closed end to about 5 centimeters square towards the mouth. The length is about 40 centimeters and it gradually tapers towards the closed end. There are four large loops at the opening. In setting, a split rattan which is securely fastened to one loop passes through all the others and is tied to a stake or to a bunch of grass, so that when a dalag, in rushing out of the nest, is caught the *bocatot* not only is not carried away but is closed also. To take the dalag out, the closed end may be opened by loosening a knot. A fisherman may set twenty or more traps of this kind at a time.

It is the setting of the trap that requires experience. The nest of a dalag is first located. Leading to the nest there is a path from the deeper water. The trap is set along the path, near and facing the nest. Grasses or other materials are placed around the nest to close all other possible avenues of escape. The dalag in coming to the nest has to pass by the outer side of the apparatus. When, however, the fisherman approaches the nest, the dalag rushes out to a place of safety towards the deeper water, and in so doing it naturally follows the old path only to land in the trap.

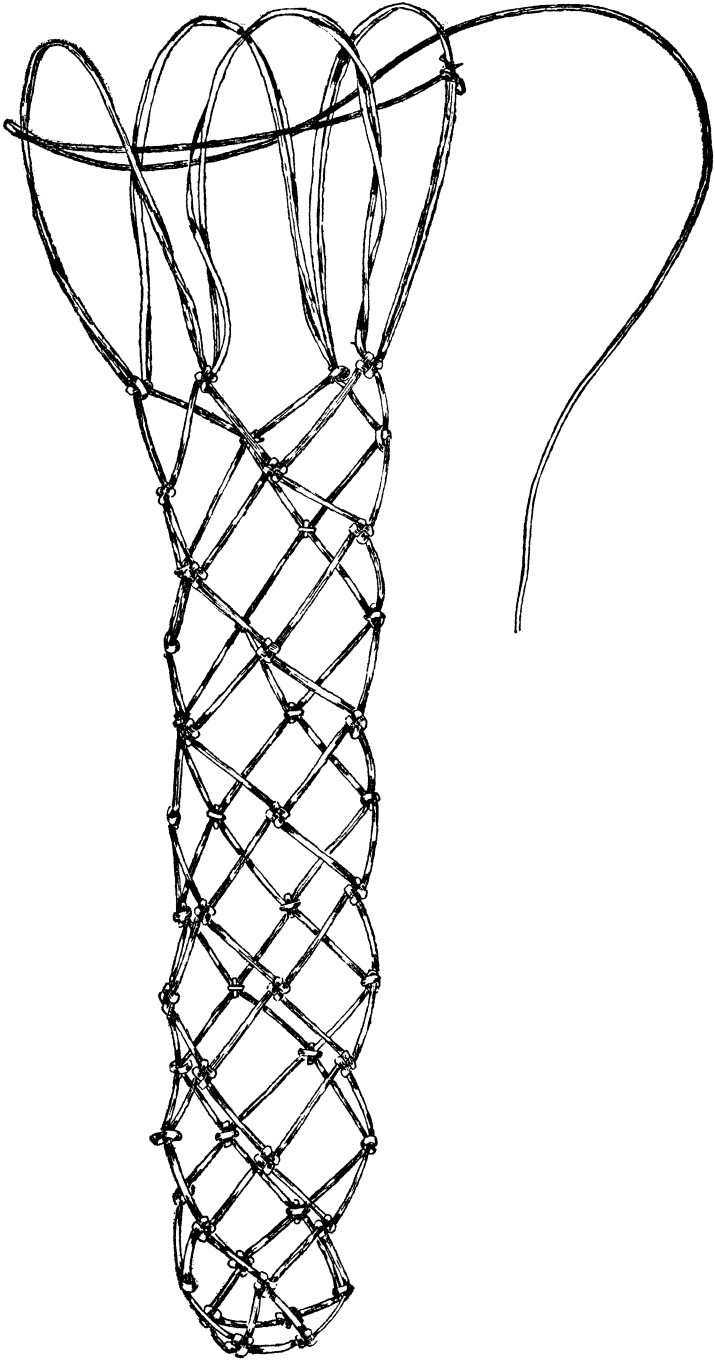


FIG. 2. Rattan bocatot.

Net bocatot.—This is the true bocatot and it depends on the speed of the current to catch the dalag. It is a bag net and its size varies (Plate 2, fig. 3). In some places where there are rivers of strong current during the dalag season, the bocatot may be of great size with a mouth almost as wide as the river itself. Around Laguna de Bay, however, smaller nets are commoner. The specimen collected is about 40 centimeters in diameter at the mouth and 190 centimeters long. There is a funnel at a little distance from the mouth to prevent the escape of the dalag. The mouth is set before an opening in the dam of a rice paddy that is being drained of excess water.

Bobo.—This apparatus works in very much the same way as the bocatot. The funnel is quite far from the opening. In order to accelerate the speed of the current on entering the *bobbo*, the part from the opening to the funnel is made to taper (Plate 2, fig. 2). The chance of the dalag to escape is, therefore, much reduced. This apparatus is set also before an opening in the dam of a rice paddy or isolated pools.

The use of bobo for catching dalag on a different principle is found along the river draining Lake Calibato into the Laguna de Bay. There is practically no soil in this river. Dams of rocks are built inclosing a rectangular space on the side of the river, its rocky bank forming one side. The inclosed space is covered with coco-palm leaves, thus providing a place of retreat for dalag which are free to come in and out of the inclosure through openings between the rocks. After a certain period, bobos are placed in holes among the rocks, with the funnel toward the inside of the dammed space. The coco-palm leaves are then taken away. The dalag being thus deprived of the protection offered by the leaves, come into the bobo as a last resort.

The same bobos are also used in catching dalag by putting them in crevices among rocks which are piled to dam a part of a river. The funnel faces down stream. The dalag in coming up the river attempt to pass through the funnel and are caught.

Bonbon.—As the name implies this is simply a pile of branches and twigs to provide a sort of playground or home for the fish. It is very common in shallow water near the shores of Laguna de Bay. Usually it is about 3 meters in diameter but may be very much larger. Quite often a hole is dug in the middle of the space to be occupied by the *bonbon*. This serves as special attraction for the dalag. After a certain period, which may vary from several days to several weeks, it is surrounded with a

baclad,³ the branches and twigs thrown out and the fish caught with a salacab (Plate 3, figs. 1 and 2).

Floating patches of water hyacinth.—This introduced water plant, *Eichornia crassipes* (Martius) Solms which has been the cause of so much regret on account of the inconvenience it is causing to shipping and fish corrals, is becoming, at least in one way, a blessing to the fishermen. It has been found that dalag and other fish are attracted to stay under the shade of these plants. Fishermen gather and maintain these plants in regular patches and now, especially along the shore from Angono to Binangonan, they may be seen at more or less regular intervals. At other places, bamboo inclosures with a few plants inside may also be seen, the evident object of the owners being to fill them up in due time with fresh collections, and failing in this, to allow the plants to multiply. It may be said, therefore, that the water hyacinth has now come to be cultivated (Plate 3, figs. 3 and 4).

After certain periods these patches are surrounded with *baclad*, the plants temporarily taken out, and the fish caught with the help of a salacab.

Pugad-pugad.—As the name implies, this is a sort of nest and may be seen floating by the hundreds in some parts of Laguna de Bay, especially along its northeastern side. It is constructed of a coarse-woven bamboo for the floor, on which is built a wall of grass and mud, making the whole affair as nearly ideal as possible for a retreat for dalag. At the side, just a little below the surface, is a small door through which the dalag enters. The roof consists of a thin straw covering.

A necessary part of this fishing apparatus is the *panaclob* which is a bag net with a strong frame. As the fisherman in his banca approaches the *pugad-pugad* quietly, he covers it on top with the *panaclob*, and at the same time with one hand he prevents the exit of the dalag through the side door. The dalag jumps through the thin roof to escape and is caught in the bag net (Plate 4, figs. 1 and 2).

Pangloob.—This fish trap is found almost anywhere around the lake in different forms, but in all cases there is a door closed by a trigger which is so placed that the dalag comes in contact

³ A *baclad* is made of bamboo splints usually from 0.5 to 2 centimeters wide and from 1 to 10 or more meters long, held together in parallel order by split rattan or other materials so as to form a sort of a matting. The term *baclad* is also used to mean a fish corral as a whole.

with it on entering the trap. In rivers, the *pangloob* is constructed by making a sort of dugout in a shaded portion of the bank (Plate 5, fig. 1). In shallow water it is made of coarsewoven bamboo set on the mud (Plate 5, fig. 2). In deep water the pangloob is a trap complete in itself and floating on the water (Plate 6, fig. 1).

Loóng.—This is essentially a hole in the ground under shallow water or along the banks of rivers, provided with branches and twigs and water plants of various kinds to attract the dalag. The hole is about a meter in diameter and less than a meter deep. The embankment is a little above the water surface. The details of the construction are shown in fig. 3. The back part of the hole is dug a little deeper than the rest, and it is here the dalag is expected to make its nest. When eggs are laid the fisherman catches the fish with a galay, or a salacab.

These traps are constructed mostly during the beginning of the rainy season when dalag are laying eggs; that is, from June to August. A fisherman may have as many as twenty of these traps at a time. As the water in the lake rises he makes new holes towards the shore.

Paluksó.—This is set up in a creek or river when the water in the lake is subsiding (fig. 4). It consists of two wings and a heart, just like an ordinary fish corral in a river, and in addition there is a platform on which the dalag land on jumping out of the water, and a live box to keep the dalag alive until the fisherman comes to collect them. To prevent the dalag from escaping, the wings and the heart rise high above the water except a part about 1.5 meters wide at the back of the heart which is only a little above the water. This part instead of being vertically set is at an angle to the surface of the water, with the lower end against the current and in contact with the bottom. As the dalag travels downstream it meets this inclined part of the heart. Either it changes its course and turns around along the side of the heart, or attempts to continue its voyage by jumping out of the heart. In the first case it is likely to continue turning around, until it finally attempts to escape by jumping out on striking the inclined back part. In the second case, jumping at this place would make the dalag land on an oppositely inclined platform which is surrounded by high fencing, thus preventing the escape of the fish. The lower side of this inclined platform is tilted at one corner which is maintained a little below the water all the

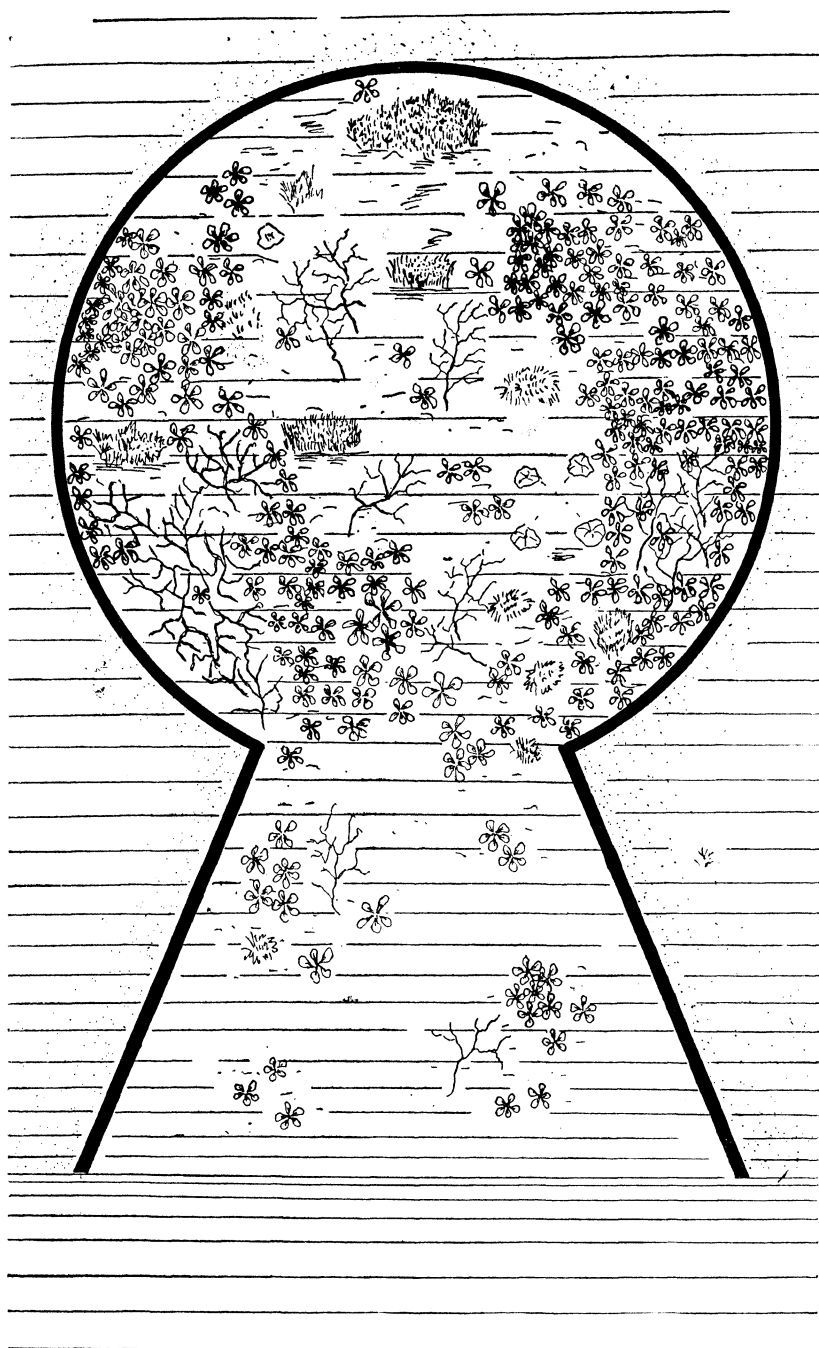


FIG. 3. Diagram to show the construction of a loóng.

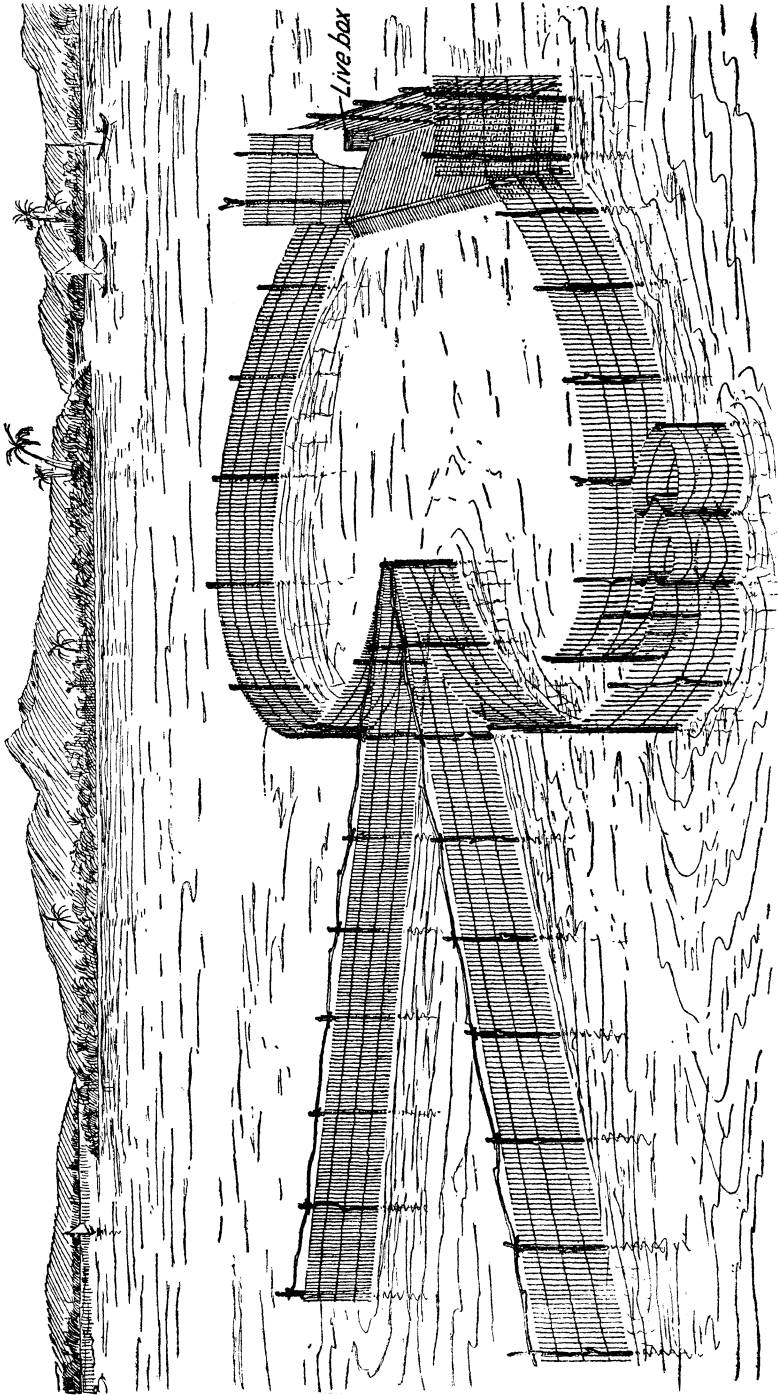


FIG. 4. Paluksó.

time. The dalag is therefore bound to go to this corner. The live box is so placed that its small side opening just fits the corner below the water. The dalag is thus very ingeniously led into the live box. This has a lid on top which the fisherman opens when he comes to collect the fish with a dip net.

In some cases a small heart is provided for by the side of the first one. The object of this is to trap those dalag which fail to jump onto the platform.

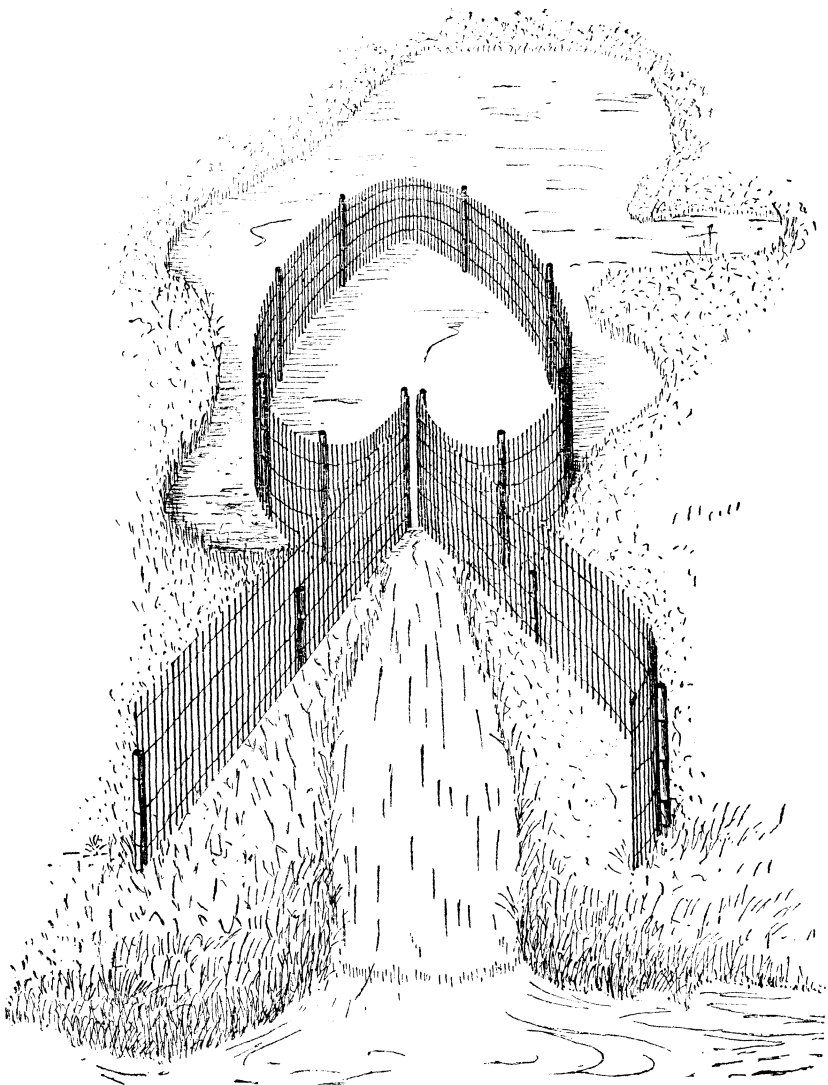


FIG. 5. Pasadsaran.

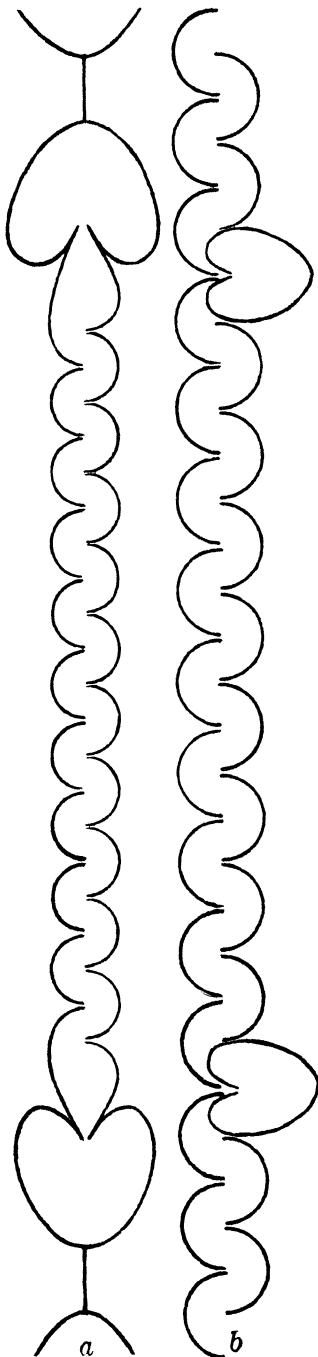


FIG. 6. Diagram, *a*, to show the setting of the kilo-kilo and, *b*, another form of the kilo-kilo.

Pasadsaran.—When the heavy rainy season sets in, that is during June or July, the dalag show a strong tendency to go up the shore. This is the time when the *pasadsaran* is constructed. This is simply an ordinary fish corral in construction having two wings and a heart, but radically differs from the latter in position since its wings face away from the shore (fig. 5). More often, however, the *pasadsaran* is constructed by first digging a canal less than a meter wide on the shore to allow the water from the background to flow through it to the lake. The dalag going up through this canal are then caught in the *pasadsaran* set in the canal.

Kilo-kilo.—This trap is a very ingenious device for catching dalag. It is placed across the mouth of a small shallow indentation which is covered with *tikiú*, *Scirpus grossus* Linnæus, f., or other growths. It consists of baclads, each about a meter long, or less, and placed on the ground in a semicircular position, overlapping each other so as to form a sort of chain. At intervals of from seventeen to twenty-three baclads there is a heart over a meter in diameter. There may be as many as thirty-five hearts in one *kilo-kilo*.

As may be seen from the diagrams (fig. 6), the opening between two semicircles is an entrance. Fish coming from the lake towards the indentation or vice-versa will, therefore, find their way into the trap through one of these many openings and finally land in one of the hearts.

Takilis.—This consists of several baclads joined so as to make a long

one and set up in a more or less semicircular form before a shallow place covered by such growths as ordinary grass or water hyacinths. Several men, each with a long pole, drive the fish from among the grass towards the baclad. As the men approach the two ends of the baclad, the semicircle is gradually narrowed near the middle of the arc until a sort of heart is formed, or the whole semicircle may be narrowed into a small circle. Then the inclosed fish are caught by means of salacab.

Saklitan.—This is a simple corral with a leader starting from the shore and a big heart. The opening of the heart is provided with two aprons which serve as gates that are closed when the dalag inside the heart are being caught (fig. 7). This corral which is mainly found along the northwestern shore of Laguna de Bay

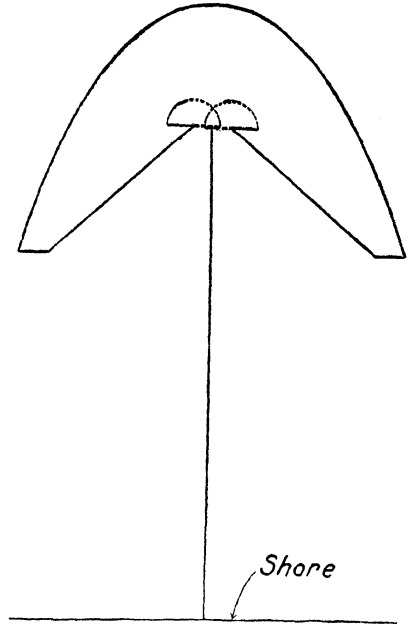


FIG. 7. Diagram to show the construction of saklitan.

is put up during the rainy season when the dalag tend to come towards the shore. As the dalag approach the shore line, being unable to progress any further, they move along the shore, hit the leader of the *saklitan* and follow it until they land in the heart. Naturally, as the water in the lake rises, the saklitan has to be moved towards the shore. To catch the dalag in the heart the fishermen use a rectangular drag net about 1 by 4 meters provided with a bag about 2 meters deep. A pole at each end serves as a handle and keeps the net stretched vertically.

Salap.—This is a dip net which is used more for catching shrimps and is, therefore, properly described under that heading. During certain months of the year, especially July, August, and September, when dalag fry are abundant the *salap* is used in catching them. The dalag fry remain in swarms for some time and it is then that the fisherman may scoop up practically all of them with a *salap*, to be either cooked for food or used as baits for kitang in catching kanduli.

METHODS OF CATCHING HITO

This species is included with the dalag and the climbing perch in the popular group known as mudfish; but while the dalag is an energetic animal, the hito is a sluggish one. It is caught with the dalag by the bobo and the panteng pukot and will take the hook also.

Salacab.—Like dalag, hito are caught by ordinary salacab singly. But hito come together in quite large numbers at times, apparently in play. To catch them while together a big salacab 1 meter in diameter at the base and about 0.75 meter in altitude is employed.

Sucob.—Another apparatus used for catching hito while they are together is the sucob, very similar to that used for dalag but smaller.

Siid.—A very interesting trap for catching hito exclusively is the *siid*, also called *bakikong* (Plate 6, fig. 2). This method of catching hito is best developed in the eastern side of Laguna de Bay, although it is also employed in other places.

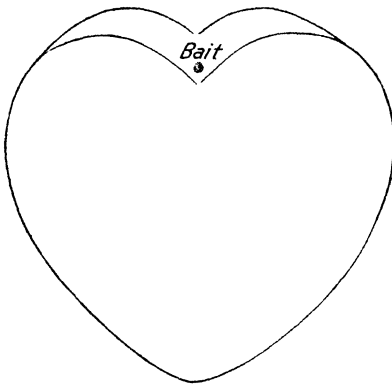


FIG. 8. Diagram to show the outline of the siid and the position of the bait.

This is a small affair and a fisherman may have as many as fifty at a time set at different places in grassy and shallow water. It is made in the shape of a heart (fig. 8). As may be seen from the diagram, before reaching the real entrance into the heart, there is another entrance formed by two aprons.

There is neither leader nor wings. The hito is attracted to this trap by means of strong smelling baits. The recipes for baits vary, and in many instances they are guarded as individual secrets.

Here are two recipes:

1. Staranise, *Illicium verum* Hooker, f.; cinnamon, *Cinnamomum zeylanicum* Blume; clove, *Eugenia aromatica* Baillon; and nutmeg, *Myristica fragrans* Houttuyn, are fried till they are crisp, ground and mixed with coconut oil to make up the stock solution. Living white ants (termites) and snails are ground and, with a quantity of the stock solution, mixed with ground clay and formed into a ball about the size of a fist. This is placed at the mouth of the heart.

2. Nutmeg, the roots of *lobigan*, *Acorus calamus* Linnæus; *mutha*, *Cyperus rotundus* Linnæus; and seeds of *Ricinus* are roasted and ground together and mixed with ground white ants, ground clay, and milk from grated coconut meat. A fist-sized ball of this mixture is placed at the mouth of each siid.

Pante.—This is practically similar to that used in catching kanduli (see below) but smaller in dimensions, being operated only in the shallows near the coast. It is commonly met with on the eastern shore of Laguna de Bay.

METHODS OF CATCHING KANDULI

Kanduli is caught in the deeper regions of Laguna de Bay. The apparatus intended to catch this fish are, therefore, so constructed that they can be operated in deep water.

Salacab.—The salacab is used also for catching kanduli. Since kanduli live in deeper water, the salacab is used a good deal below the surface. Indeed, men fishing for kanduli with salacab work in water breast or neck deep. The operation of the salacab in catching kanduli is much the same as in catching dalag. However, when a kanduli is felt inside, one foot instead of a hand is inserted slowly through the upper mouth of the salacab and the kanduli carefully and firmly pressed down under the foot against the mud so that it cannot move. Then, with a single pronged spear about a meter long, including the handle, the kanduli is transfixed, the spear passing between the toes of the fisherman.

Pukot laot.—This is the most expensive of all fishing gears in Laguna de Bay, some of them costing as much as 2,000 pesos. It is a pukot dalag on a much larger scale, and catches kanduli instead of dalag for the simple reason that the latter fish is limited to the shallower water near the shore. Some pukots are 2,000 to 3,000 meters long and wide enough to be operated in any part of the lake. From thirty to fifty men are employed in the handling of this net. Of these, about twenty pull the net, and four or more dive to see that the bottom line is in good contact with the bottom or buried a little in the mud. The rest collect the net into the banca, or do other things.

During the spawning season, from February to May, inclusive, it is said that kanduli do not move much, and this is the time when big catches are expected. A kanduli school is not readily located, but birds sometimes give indications of its presence.

Aside from *kanduli*, *biang puti*, *Glossogobius giurus* (Buchanan Hamilton) are also caught in large quantities.

Pante.—This is a gill net and is the commonest net gear that is found around Laguna de Bay. It is provided with floats but carries no weight, the bottom part of the net sinking of its own accord. Depending on its length, which may be 1,000 meters, although it is usually less, one or more men are required to operate it. It is always wide enough to leave a good margin lying on the bottom when set. This provision is necessary because *kanduli* stay at or close to the bottom. The mesh is about 5 centimeters stretched. The *pante* is allowed to drift with the current and is usually operated in the night.

A very recent development is a *pante* having a 10-centimeter mesh. Naturally, only big *kanduli* are caught. The *pante* is sometimes placed in water in a more or less circular form, and the fish are driven to the net by beating the water from the center. This is usually operated in the day time.

Tilay.—This is simply a hook and line, but its use for catching *kanduli* requires experience and patience. A banca of special make, that is, one with an angular bottom instead of an ordinary flat one, is employed. The object of the angular bottom is to avoid the noise which a flat one makes against the waves. A small paddle with a short handle operated with one hand is employed, the other hand being left free to manipulate the line.

The baits consist of living young *kanduli* a few centimeters long. These are placed in water under the fisherman's seat, so that when he needs one he does not have to move about and create noise to get it. He uses a small dip net to get a bait.

The fisherman takes advantage of the wind and drifts slowly with it while fishing.

Kitang.—This is a trawl line carrying at times from two to three thousand hooks suspended from it by short lines about two-thirds of a meter long and one and one-third meters apart. Among the baits used are shrimps, small crabs, *ayongin*, *bañgay-ñgay*, earthworms, snails, and the small bulbous petioles of water hyacinth (Plate 7, figs. 1 and 2).

A man engaged in *kitang* fishing has to have other fishing apparatus also for getting the baits. He may have a number of *bonbon* that would give him daily enough shrimps for baits; or a *sakag* to catch *ayongin*. Several *kitang* fishermen may work together and combine their trawl lines. They may then

catch baṅgayṅgay, small kanduli, and others with a *sikit*, which is a sakag and a long chain requiring several men to operate.

Casting net.—This net is also used for catching kanduli. Usually three men go together to fish with this apparatus; two row the banca while the third manipulates the net, observes the movement of the fish, and throws stones to the spot to be covered by the net. The object of throwing stones is to make the fish stay at the bottom and to direct the course of the boat. The net is slowly lifted out of the water and the catch taken into the banca.

Sakag.—This fishing gear is primarily for catching ayoṅgin and is, therefore, properly described under that heading, but at times large quantities of young kanduli are caught with it.

Fish corrals.—These are numerous in Laguna de Bay and when located in deeper water catch kanduli mainly (Plate 8, fig. 1). In ground plan they are mostly of the type shown in the diagram (fig. 9). The leader is perpendicular to the shore line. In some places the corrals are arranged in series starting from near the shore and varying from several to twenty or more in each series.

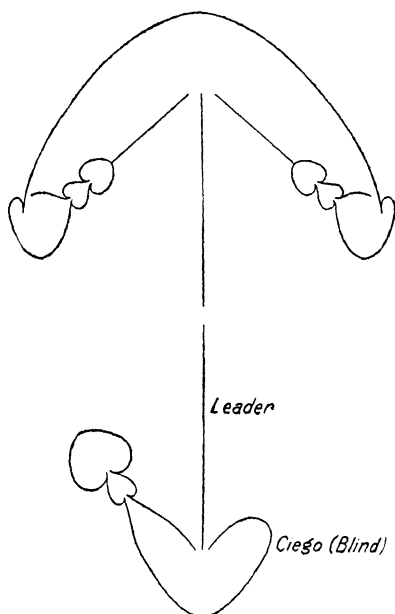


FIG. 9. Diagram to show the construction of a fish corral in Laguna de Bay. Usually the unsymmetrical head known as ciego (blind) is omitted. The ciego is said to catch more fish at the beginning of the rainy season, because at that time the fish move towards the shore.

METHODS OF CATCHING GOBIES

The most important of the gobies caught in Laguna de Bay is the biang puti. The *dulong*, *Mirogobius lacustris* Herre, is caught in large quantities during the rainy season.

Bobo.—The practice of catching biang puti by means of the bobo prevails in many places around the lake, but in Cardona, Rizal Province, both the catching of the fish and the

manufacture of bobos have become quite an industry. Here the bobos are made in large numbers and placed at the bottom of the lake. They can be bought at a very reasonable price, around 15 pesos a hundred. The maker also sets the bobos in the water for any fisherman at about 20 pesos a hundred, including the cost of the bobos themselves.

The bobo is made of woven bamboo shaped much like the ordinary jar or demijohn without the spout. It is about 60 centimeters high and about 35 centimeters at the widest diameter. To the uninitiated, bobos piled by the roadside, which is a usual sight in Cardona, appear like so many demijohns, each inclosed in wickerwork (Plate 9, figs. 1 and 2; Plate 10, figs. 1 and 2).

These bobos are placed at the bottom of the water, about a hundred at a time, securely attached to a long vine of *hinggiú*, *Ichnocarpus volubilis* (Loureiro) Merrill, about 2 meters apart. The fisherman uses a triple-hooked iron rod (Plate 8, fig. 2) in bringing the main line to the surface of the water in order to look into each bobo for imprisoned gobies.

Pante.—This is a drifting gill net with a mesh of about 5 centimeters stretched and usually of No. 40 cotton thread. It is kept soft and white by being treated with white of duck eggs and then steamed. After this treatment the net is re-steamed after using it the second and fourth times, and after the sixth time it is again treated with white of eggs and steamed.

Pandulong.—During the rainy season large quantities of dulong appear near the shore. The fisherman builds a leader from the shore consisting usually of leaves of coco palm or banana tied to a series of bamboo stakes in a straight line. The more permanent ones are strongly built of large bamboo stakes and woven pieces of bamboo instead of coco or banana leaves. The dulong in their movement along the shore follow the leader, at the end of which they are collected in large numbers into a salap.

Sikit.—This apparatus consists of a sakag and a long iron chain or a rope to which are tied dried banana leaves. The sakag is set up and supported by stakes. Then, starting from a distance, the chain is dragged towards the sakag by two men each holding an end. The sakag is then lifted and the catch collected, and another place is chosen to repeat the same operation.

The catch consists mainly of *baṅgayṅgay*.

In many cases this apparatus forms a unit with the kitang and is used only to catch baits for the latter.

METHODS OF CATCHING AYONGIN

Ayongin is not a highly prized fish, being small and possessing stiff bones, but its abundance at times in some localities has made it popular among the poorer class. When small, about 2 or 3 centimeters in length, it serves as bait for kitang. Ayongin go in schools on the surface of the water and are, therefore, readily located by fishermen.

Hook and line.—A considerable quantity of ayongin are also caught, usually by women who use hook and line with a rod about 2 meters long. The bait consists usually of pieces of fish, shrimps, and earthworms.

Sucob.—The sucob that is used to catch ayongin is quite similar to the one used for capturing dalag, but it is much lighter and has a long handle which is the projection of the vertex of the cone. It catches the ayongin by the gills as they rush out after being covered by the sucob. Those that escape being caught by the gills in the net are captured in the temporary bag formed by the side of the frame when the trap is lifted (Plate 9, fig. 3).

Sakag.—In shallow water this net is held by one person in a place, while one or two others walk from a distance and drive the ayongin into it. The sakag is lifted to collect the catch and then another place is chosen. Sometimes one or two men may push this apparatus to catch the fish (Plate 11, figs. 1 and 2). In deeper water the fishermen, usually three in number, go in a banca, two rowing and one handling the sakag. Small kanduli in large quantities are also caught by this method of fishing, especially during the beginning of the rainy season.

Corral.—In shallow places near the coast, with water 1 to 2 meters deep, corrals are constructed mainly to catch ayongin. In ground plan the corral is just like any other corral. This fish corral is sometimes known as siid, though differing from the true trap of this name.

METHOD OF CATCHING TALILONG

Pante.—The pante for talilong is kept soft and white by treating with white of duck eggs and then steamed like that for biang puti. The net, however, is of lighter thread and finer mesh.

METHOD OF CATCHING SAWFISH

This fish is caught in the deepest parts of Laguna de Bay, especially in the strait between Morong Peninsula and Talim Island, and the deep between Talim Island and Jalajala Point. A pante, made of heavy twine and having a mesh of about 46 centimeters stretch, is used. Only a few fishermen are engaged in this kind of fishing.

METHODS OF CATCHING SHRIMPS

The small shrimps caught in Laguna de Bay, while not the kind that find ready acceptance among the more-prosperous class, nevertheless form an important source of animal food on account of their abundance and the ease with which they are caught. Large quantities of shrimps, mainly of the families Atyidæ and Palæmonidæ, are used as fertilizer for betel plants, *Piper betle* Linnæus, which are extensively cultivated in some parts of the Laguna de Bay region, and also as feed for the domesticated ducks.

Salap.—Shrimps, mainly of the smaller kinds are fond of staying in weedy places, especially in water with a good stand of tikiú. To gather shrimps in this environment the salap is employed.

There are two kinds of salap. One is a dip net of about a centimeter mesh or finer, mounted on a circular bamboo frame with a short handle (Plate 12, fig. 2). The opening of the frame is about 120 centimeters in diameter and the net itself is about 1 meter deep. The other consists of a net of fine mesh or of sinamay mounted on a rigid triangular bamboo frame or on only two pieces of bamboo crossed near one end. The last two are sometimes handled by two men or women. The fisherman walking along a shallow place near the shore or standing in a banca, if the water is deep, applies the edge of the salap against the sedge. He lifts the salap out of the water every now and then to put the catch in the basket or in the banca. In the rainy season shrimps in considerable quantities are caught with salap even in water without plant growths. In the night, lights are used to attract the shrimps. In this case a light is suspended at the end of a stake and a man or woman pushes a salap around near the stake; or there may be a leader at an oblique angle to the shore and the light is placed at the end towards the shore where the shrimps are caught with a salap.

Bonbon.—In shallow water not inhabited by water plants, fishermen have conceived the idea of providing homes for the shrimps in the form of bonbons. The bonbon consists of twigs of various kinds of trees bundled together and placed under the water (Plate 12, figs. 1 and 2). When the fisherman comes around, he lifts the bonbon and inserts a salap beneath it before it comes above the water. The shrimps fall into the salap.

Bonbon fishing for shrimp is an extensive industry in some parts of Laguna de Bay, and the making of bonbons is an occupation engaged in by some people. The shrimps caught are mainly the larger species (*Palæmon*), which are sold for human consumption.

METHODS OF CATCHING CRABS

Crabs are caught in quantities by using baits of *tikitiki*, copra meal, cooked rice or meat in streams emptying into the lake. Jute sacks with a circular frame at the mouth, pots or tin cans are used for traps. The crabs are used as baits for kitang, besides being eaten by people living around the lake.

FISH POISONS

In Laguna de Bay fish poisons are evidently not much used. The collecting and preparation of the poison material, the uncertainty of catching enough fish to pay for the trouble, the undesirability of the fish caught, because usually dead, and the fact that it is forbidden by law, all contribute to the unpopularity of the method.

But once in a while, especially during certain seasons when fish are plentiful near the shore, fish poisons are employed. There are several fish poisons known among fishermen around the lake and the use of these is many times shrouded with superstition. Probably the best known of these fish poisons is the *palis*, *Callicarpa cana* Linnæus. The leaves are ground and spread on the surface of the water. *Bayag-usa*, *Gardenia curranii* Merrill and *hanumi*, *Diospyros multiflora* Blanco are known for their fruits which are powdered and spread on the water surface.

THE COLLECTION OF SHELLFISH AS FEED FOR DOMESTICATED DUCKS

The extensive duck industry around the shore of Laguna de Bay is dependent mainly upon the availability of shellfish in the lake. The duck's tendency to lay eggs is known to be

very sensitive to changes in the quantity and quality of feed and regularity of feeding. Duck tenders say that even the localities from which the shells come have a marked influence on the egg-laying capacity of the ducks. Often the shells are cooked before feeding.

It is estimated that a duck consumes about 1 to 1.5 liters of shellfish a day, so that a flock of a hundred will keep a man busy gathering shells every day or every other day.

To gather shellfish from the bottom of the lake a man stands in a banca and, holding the handle of the scraper with two hands, scrapes the bottom of the lake, (Plate 11, figs. 3 and 4). In some cases the scraper, heavily weighted and attached to a rope, is dragged along the bottom from a moving sailboat. Mainly *suso*, *Vivipara angularis* Müller; *sambuele*, *Melania* spp.; and *tulla*, *Cyrena* (*Corbicula*) *manillensis* Philippi are obtained.

Usually attached to various kinds of water plants are the *cohol*, and *anod-anod*, *Amphipeplea* sp. These are gathered with the help of a small dip net.

The *tulla* and the *cohol* also serve as human food, and the latter is used as bait for *dalag* and *kanduli* besides.

ILLUSTRATIONS

PLATE 1

- FIG. 1. Two men on their way to the fishing grounds. The man on the left carries the fishing accessories, which consist of two salacabs, one inside the other, and two creels.
2. Sucob for dalag being carried on a banca. The part of the net above the vertex of the conical frame is tied into a knot.

PLATE 2

- FIG. 1. Alcabus.
2. Bobo for dalag.
3. Small net bocatot.

PLATE 3

- FIG. 1. Bonbon for dalag, close view.
2. Bonbons for dalag. In the background are fish corrals.
3. Floating patches of water hyacinth under which dalags are fond of staying.
4. Close view of a floating patch of water hyacinth.

PLATE 4

- FIG. 1. Pugad-pugad.
2. Pugad-pugad being visited by the owner. The panaclob is just being taken off showing a dalag caught in the net.

PLATE 5

- FIG. 1. Pangloob in a river bank.
2. Pangloob set on mud with the door taken away. In the rainy season the major portion of the trap is under water and it may then catch dalag.

PLATE 6

- FIG. 1. Floating pangloob among growths of baino (*Nelumbium nelumbo*).
2. Siid in position.

PLATE 7

- FIG. 1. Fisherman rearranging the hooks of his kitang after fishing.
2. Drying the kitang.

PLATE 8

- FIG. 1. Fish corral in Laguna de Bay showing the leader and the left side of the head. The stakes and the ropes show the presence of bonbon for shrimps.
2. Triple-hooked iron with a long cabo-negro rope. This instrument is dragged along the bottom of the lake to locate and bring to the surface the main line to which are tied in a series a number of bobos, in order that the imprisoned gobies may be collected.

PLATE 9

- FIG. 1. Bobo for goby (*Glossogobius giurus*).
2. Bobo for goby with the bamboo stopper off.
3. Sucob for ayongin.

PLATE 10

- FIG. 1. Man of Cardona making a funnel for a bobo. Note the revolving conical block of wood on which he is building the funnel.
2. Same man building up the main body of the bobo on a finished funnel.

PLATE 11

- FIG. 1. Pushing a sakag.
2. Lifting a sakag in order to take out the catch.
3. Scraping the bottom of the lake for shellfish.
4. Putting the shellfish into the banca.

PLATE 12

- FIG. 1. Stakes to each of which is tied a bonbon for shrimps. In taking the bonbon to the surface of the water the fisherman pulls the rope.
2. Fisherman collecting the shrimps from a bonbon by taking it out of the water, placing a salap beneath before it comes above the surface.

TEXT FIGURES

- FIG. 1. Diagram to show the positions of the banca, which carries the men, at different stages of pulling the net of a pukot dalag.
2. Rattan bocatot.
3. Diagram to show the construction of a loóng.
4. Paluksó.
5. Pasadsaran.
6. Diagram, *a*, to show the setting of the kilo-kilo and, *b*, another form of the kilo-kilo.
7. Diagram to show the construction of a saklitan.
8. Diagram to show the outline of the siid and the position of the bait.
9. Diagram to show the construction of a fish corral in Laguna de Bay. Usually the unsymmetrical head known as ciego (blind) is omitted. The ciego is said to catch more fish at the beginning of the rainy season, because at that time the fish move towards the shore.



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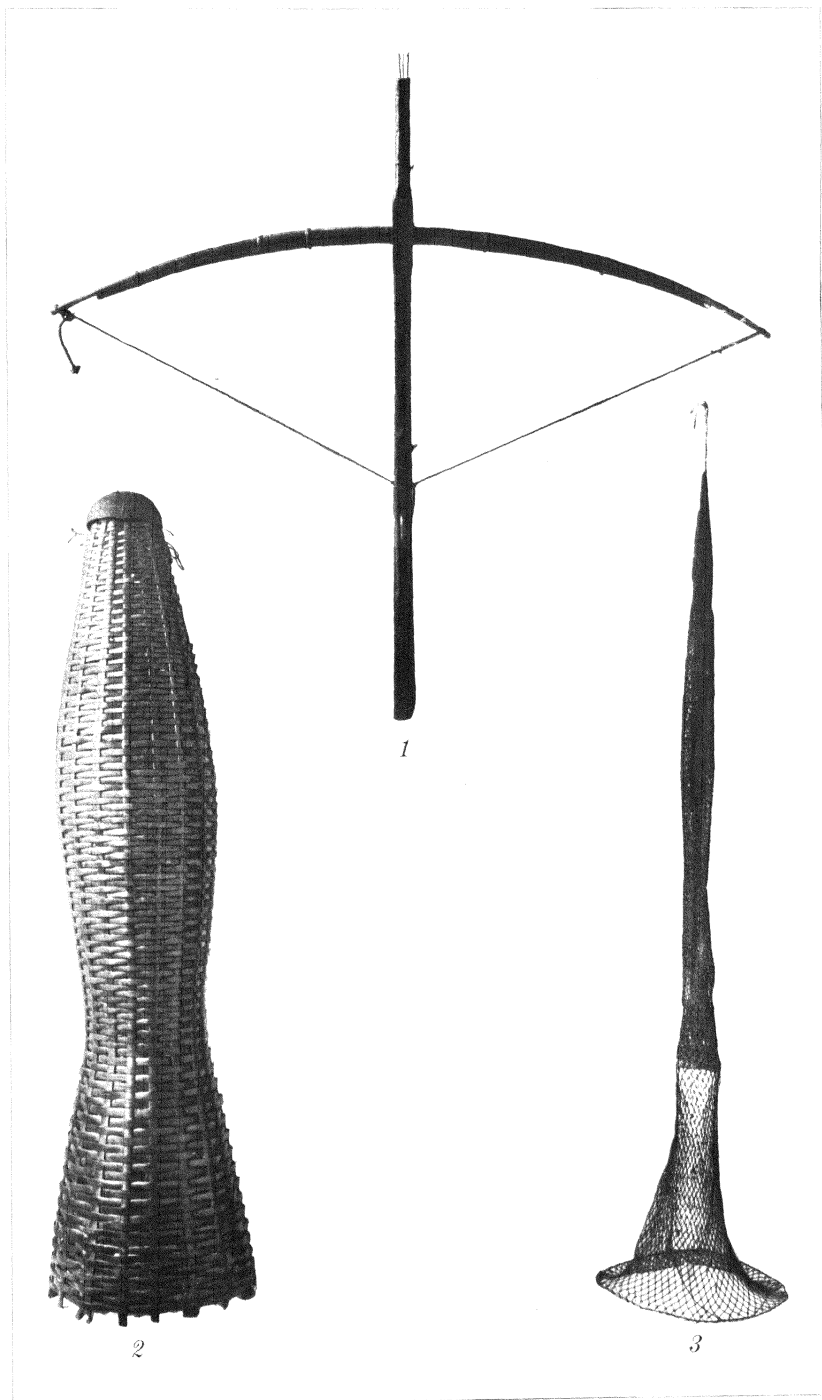


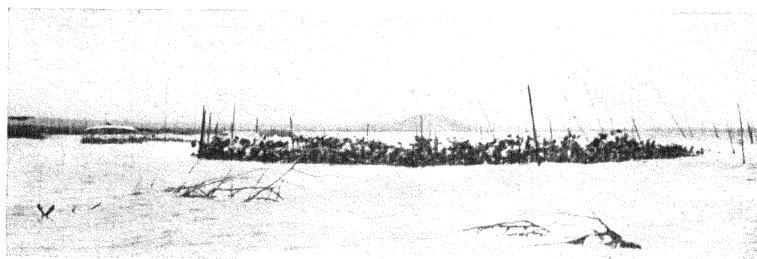
PLATE 2.



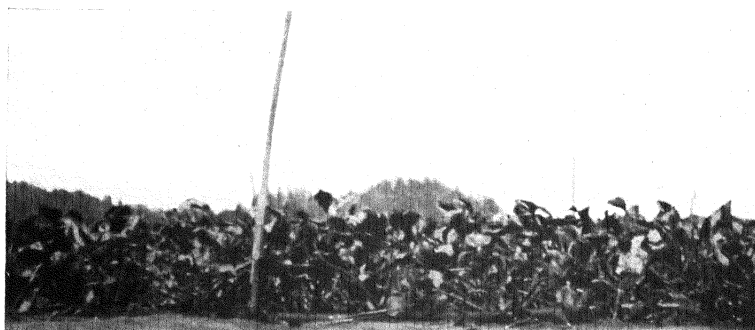
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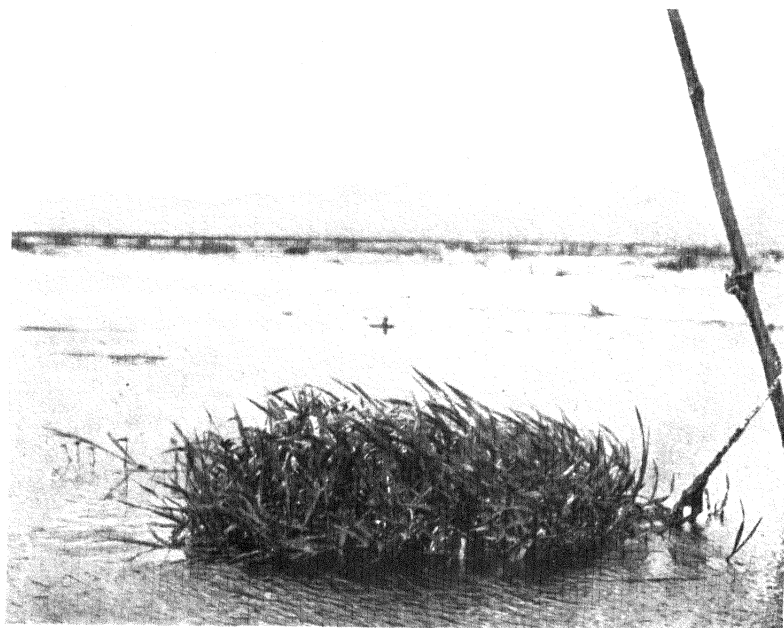
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4



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2

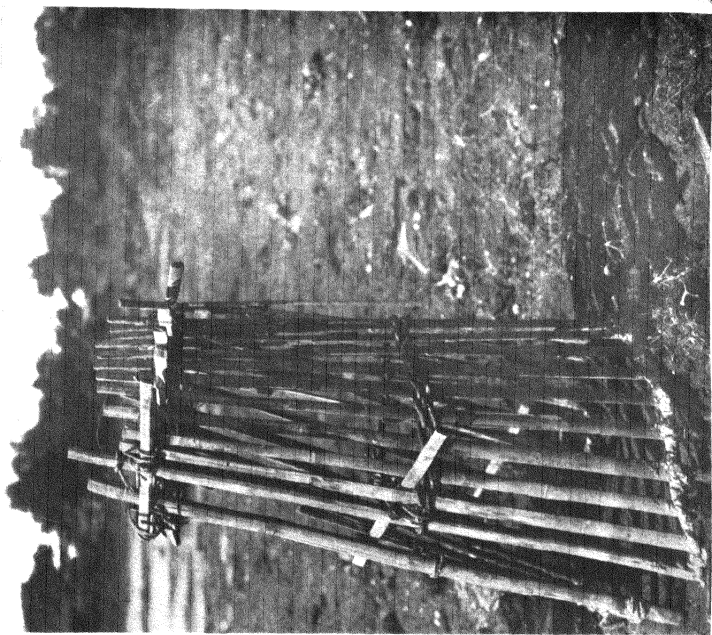
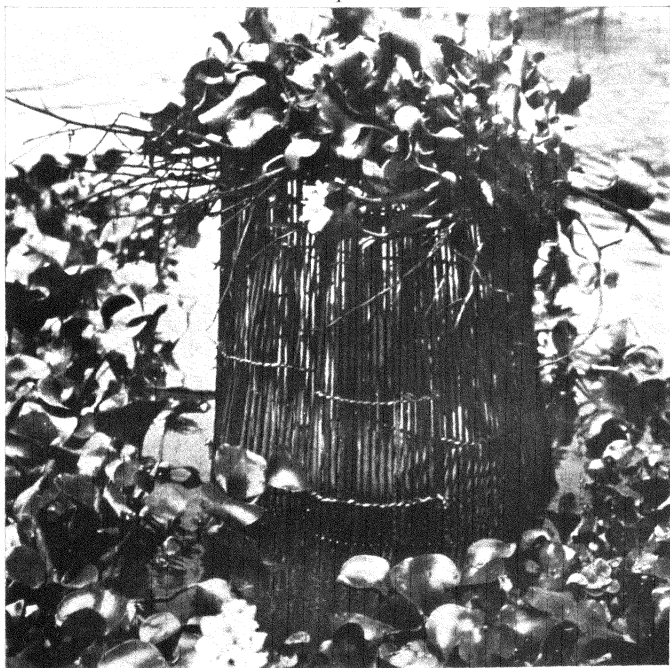


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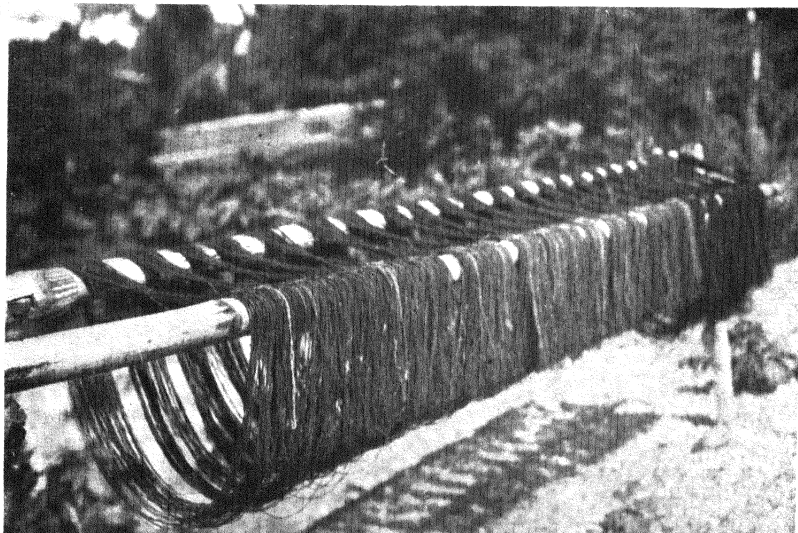
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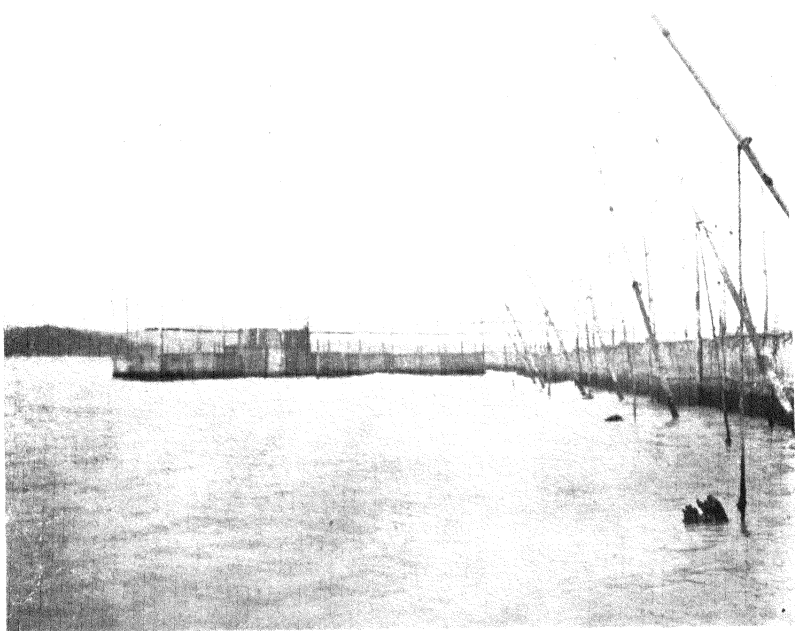
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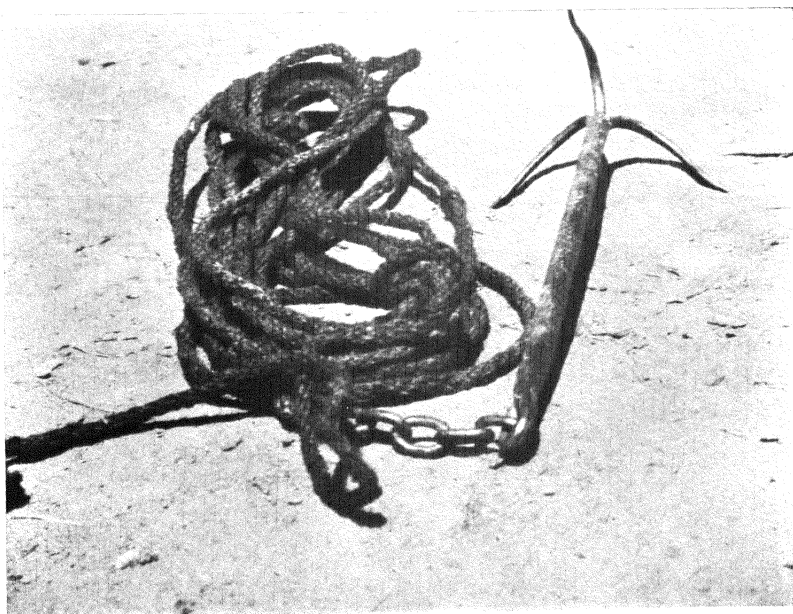
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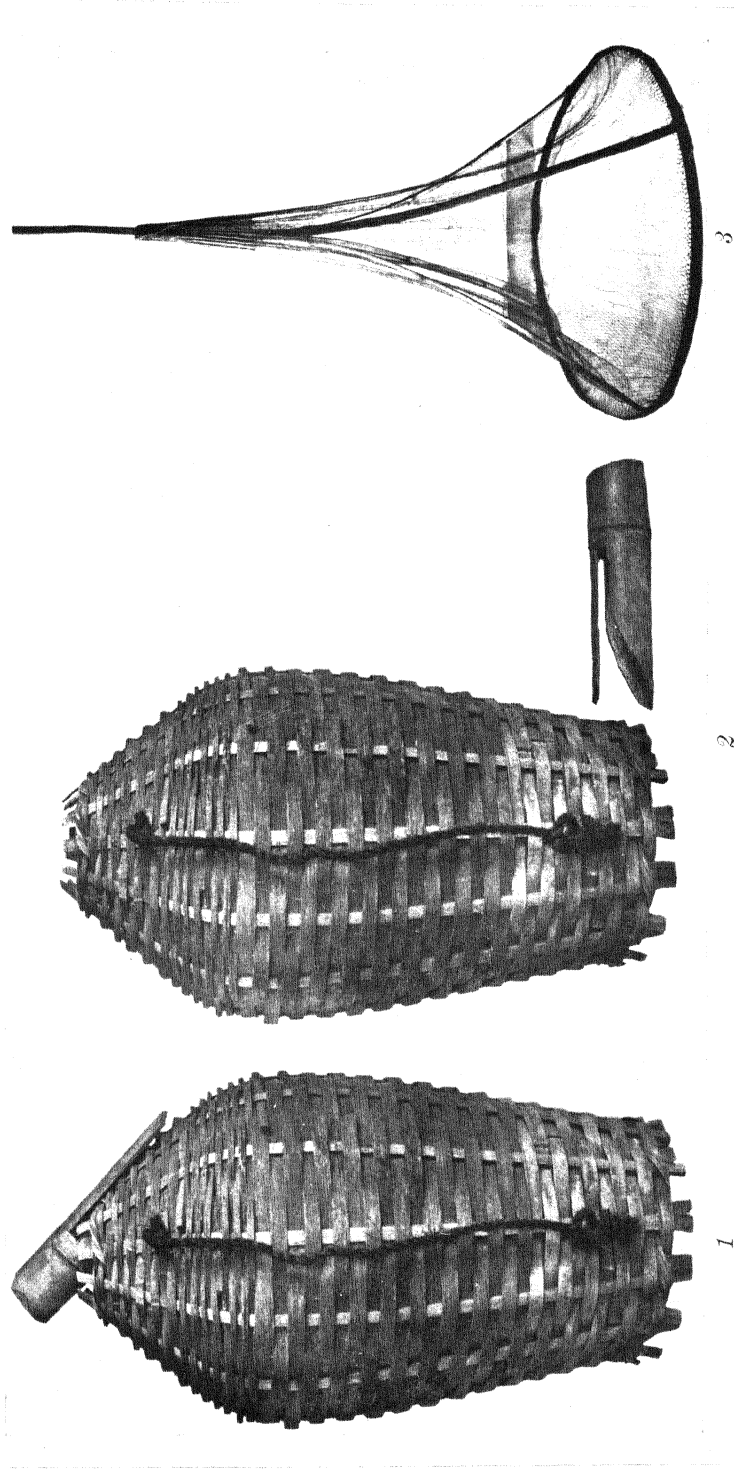
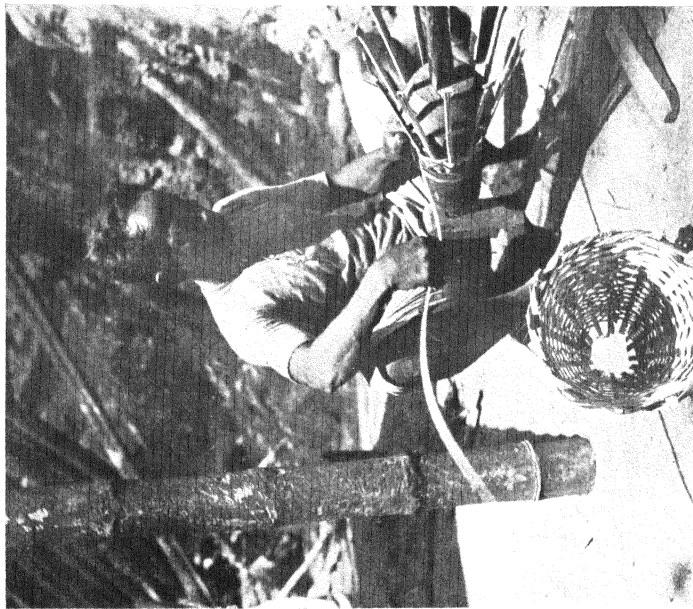


PLATE 9.

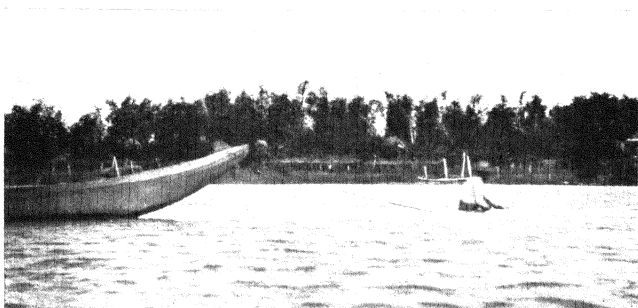


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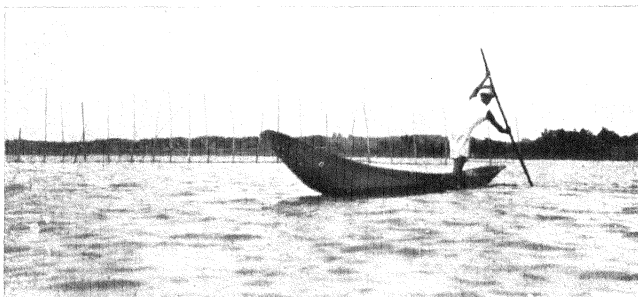
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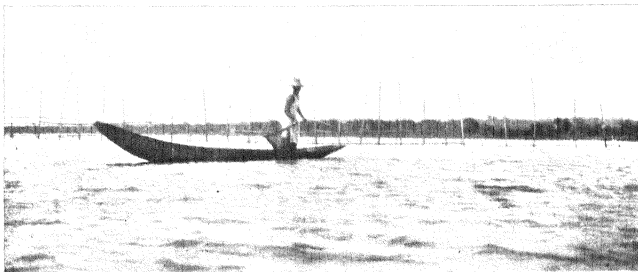
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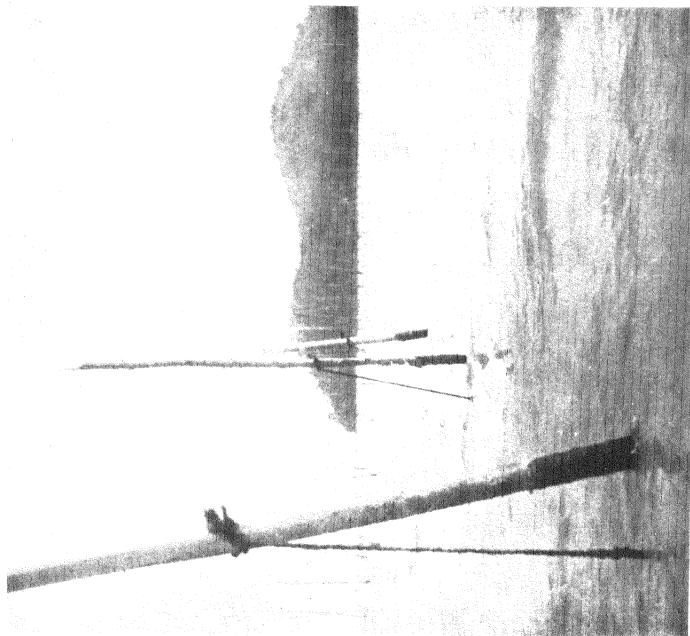
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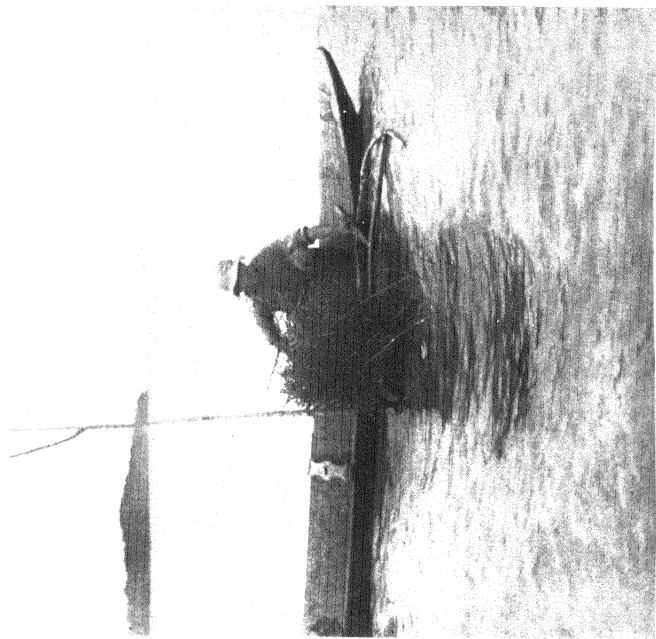
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4



1



2

PLATE 12.

THE KANDULI FISHERY OF LAGUNA DE BAY

By VICENTE C. ALDABA

Of the Bureau of Science, Manila

INTRODUCTION

If quantity alone is considered, *kanduli* (family Ariidæ) is the most important fish in Laguna de Bay. It is not as valuable as *dalag* since it is considered an inferior fish, but because of its abundance and availability at all times the people living on the border of the lake make it their mainstay in animal food.

It is interesting to note that *kanduli* finds in Laguna de Bay the most suitable conditions for breeding and growth and multiplication. In no other fresh-water lake in the Philippines does *kanduli* even approach its abundance in Laguna de Bay. Just what the ecological conditions are in the lake that so favor the maintenance of a large *kanduli* population are practically unknown. In this connection it would be worth while to describe Laguna de Bay briefly, since by so doing an insight may be obtained into the adaptability of the lake for *kanduli*.

DESCRIPTION OF LAGUNA DE BAY

Laguna de Bay lies southeast of Manila Bay and is separated from the latter by a strip of land, roughly ten kilometers wide. It is over 2 meters above sea level. It covers an area of 930.7 square kilometers, excluding Talim Island, and is the largest fresh-water lake in the Philippines. It is irregular in outline, the northern part being divided into three lobelike sections by Jalajala Peninsula and Binangonan Peninsula with its southern continuation in Talim Island. Numerous small streams empty into it, but it is drained by only one river, the Pasig. The water level rises rapidly in the rainy season and subsides rather slowly. The bottom has naturally become muddy. The floor is practically level, the depression from the coast being gradual from all sides. With the exception of Diablo Pass, which is simply a short, narrow, deep strait between Talim Island and Binangonan Peninsula, the deepest portions in various sections of the lake during the height of the dry season vary from

about 4 meters (13 feet) in the western part to about 5 meters (16 feet) in the southern.

GENERAL DISTRIBUTION OF KANDULI IN THE LAKE

Kanduli dominate the deeper regions of the lake. At a depth of about 2 or 3 meters, the smaller kanduli are caught in *sakag*, corrals and other fishing apparatus. The larger individuals live in the deepest portions of the lake.

The explanation of this distribution of small and large kanduli may be found in the fact that young fish are largely herbivorous, and the old are mainly carnivorous and even cannibalistic. This may be easily demonstrated by opening the alimentary system of kanduli and is a fact well known among the fishermen. Figures obtained by Mane¹ confirm this assertion. Naturally, young kanduli are attracted towards the shore to feed. Here they also obtain their animal food requirements in the form of shrimps and other small crustaceans. The bill of fare of the old kanduli consists principally of smaller fish which are obtainable in deep water. The larger fish have a tendency to stay at the bottom where they probably obtain the snails that are usually found in their stomachs.

SPECIES OF KANDULI IN LAGUNA DE BAY

Five species of kanduli have been reported in Laguna de Bay; namely, *Arius goniaspis* Bleeker, *A. dispar* Herre, *A. thalassinus* (Ruppell), *A. manillensis* Cuvier and Valenciennes, and *Hemipimelodus manillensis* (Cuvier and Valenciennes). Certainly, the kanduli found daily in the markets are mainly *A. manillensis*. Since all the species are quite similar in outer appearance, it is not easy to differentiate the various species that may be found in a pile.

BREEDING HABITS

The breeding habits of kanduli are very little understood. The fact that they stay in the deeper regions of the lake renders it hard to make direct observations. When it is considered that there are a number of species, which are not readily distinguished one from another, it is not surprising that so little is known about the habits and life history of these species.

Spawning.—Fishermen are very well acquainted with the fact that spawning goes on during the height of the dry season; that is, from February to May. The greatest activity takes

¹ Philip. Agriculturist No. 2 18 (July, 1929).

place during March and April. The characteristics of spawning kanduli and of males carrying eggs in their mouths, which are of great importance to the fishermen, especially to the *pukot* operator, are that they appear to be in schools or at least are together and that they do not move around much. Therefore, when a good catch is made in one spot, it is very likely that similar luck would attend the fisherman's efforts next day in places adjacent to the first one. The other fishermen are quick to learn the news and soon a number of them are flocking around the place where the first catch was made. Thus the most critical moment in the life of kanduli, or when they are most likely to be caught, is during the spawning season.

Kanduli spawn in the deepest parts of all the more or less well-defined sections of Laguna de Bay, but they are also caught with mature eggs in places as shallow as 3 meters.

Incubation.—That the eggs are kept in the mouth of the male during incubation is readily observed, and is generally known among fishermen. Kanduli with eggs in their mouths may be observed even in the market during spawning months. The writer has been informed that at times when pukots are making large catches the eggs collected may aggregate a ton. In any event there are people who are making good money by diving for and selling the eggs which have been dropped on the muddy bottom by the kanduli during the confusion which takes place when they try to escape from the pukot bag. While information concerning the quantity of eggs collected during a lucky haul may be exaggerated, still it shows in a very realistic manner the destructiveness of catching kanduli during the spawning season. Certainly with these habits of kanduli which allow them to be so easily caught in quantities while spawning and incubating, the heavy depletion of the kanduli fishery is bound to result sooner or later as an outcome of the rapidly growing human population around the lake, unless fishing is properly regulated.

There is a redeeming circumstance, which prevents the total depletion of the kanduli fishery, and it is not unlikely that it is due to this that the kanduli population of Laguna de Bay has not as yet been very seriously reduced in quantity, in spite of the heavy fishing during the spawning season. This saving factor is the existence of a large number of corrals in deep sections of the lake. In many places a corral, once put in the water, stays there until it has become so weak as to be readily torn to pieces by the action of the waves. Then the owner sets

up another, not in the same place but usually near it. In the place of the old corral are the stumps of the old stakes, which make it impossible to operate a pukot without the danger of tearing the net. It is known that kanduli with eggs are fond of staying among these stumps and other remains of old corrals. Pukot operators know these places and avoid them.

By way of explanation it should be added that the period of incubation, as the phrase is used here, includes what properly belongs to brooding, since young kanduli are set free only when they are actively swimming and the yolk is used up. It is calculated that this brooding period may cover about two months.

GROWTH OF KANDULI

It has not yet been possible for the writer to make direct observations on the rate of growth of kanduli in Laguna de Bay and the data given in published literature which have been determined by indirect methods do not appear to justify their being included here to become a basis for practical recommendations.

MARKETING

Before taking up the methods of fishing and the measures for the protection of the fishery, the subject of marketing may first be discussed, since the preference of the consumer has a good deal to do with the size that the fishermen should catch. Kanduli eggs, young and small fish, as well as the old and large are all sold in the market so fishermen catch all sizes. The small kanduli which are not sold fresh are split and dried and put in the market as *daing*. When there are plenty of fish, even the large ones are dried and marketed in towns away from the lake. However, there are times when large quantities of very young fish are just dumped in places to rot because of lack of market.

METHODS OF FISHING AND FISHING GEARS

The methods of catching kanduli in Laguna de Bay have been discussed in a separate paper, "Fishing methods in Laguna de Bay." They will be discussed here only in so far as their importance to the fishermen and destructiveness to the fishery are concerned.

The *pante* (gill net) is certainly the most important fishing gear for kanduli, although the pukot is the most conspicuous on account of its size and the number of men necessary for its operation. Naturally, the occasional large catch of a pukot

makes this net a more interesting topic for conversation, but the pante, on account of the number of individuals employing it, the amount of capital invested, and the quantity of fish caught, certainly ranks first.

The pukot is nonselective and catches fish of all sizes that may happen to be inclosed in the net, but the main concern with this fishing gear in connection with the protection of kanduli lies in the fact that it catches kanduli with eggs in large quantities. (In the phrase "kanduli with eggs" is included not only the female with maturing eggs but also the male carrying eggs in the mouth.) Indeed, in operating the pukot the fisherman counts on the fact that during spawning and incubation kanduli come together in the deep places and move very little. Very small kanduli are also caught in the pukot at times.

The pante does not catch small kanduli. In order that kanduli may be caught in this apparatus, they must be moving in the water. Since kanduli with eggs stay quiet at the bottom they are not likely to be caught in quantities. The water is, therefore, beaten hard to scare the fish. They are then caught in the net.

The other fishing gears of importance are corrals, *kitang*, *sakag*, and *dala*.

The corrals do not catch kanduli with eggs to any large extent. It is in the fact that corrals may catch large quantities of small kanduli that they are included in this consideration of the protection of the kanduli fishery.

There are, for practical purposes, two kinds of corrals to be considered. The one for *ayoŋgin*, sometimes known as *siid*, is planted near the shore, that is, in shallow places, and while it catches mainly *ayoŋgin*, *Therapon argenteus* (Cuvier and Valenciennes), it also catches half-beaks (Hemirhamphidæ). When the water in the lake is turbid, which occurs particularly in the rainy season, large quantities of very young kanduli may come into the corrals. When the market happens to be scantily supplied with fish, these fingerlings may be sold, otherwise they are just dumped somewhere to rot.

The deep-water corrals, which are more numerous than the former kind catch *biang puti*, *Glossogobius giurus* (Buchanan Hamilton) and kanduli mainly. In the southwestern part of the lake the deep-water corrals are set only during the southwest monsoon, which coincides practically with the rainy period,

and then are taken ashore for the next season. In the other parts of the lake the corrals are permanent; that is, once set in the water they are allowed to stay there as long as the parts hold together. As in the shallow-water corral, young kanduli in large quantities may come in at times.

The kitang, which is a trawl line carrying several thousand hooks at times, although a very important fishing apparatus, is not involved in the solution of the problems concerning the protection of kanduli. It catches only kanduli of good size that are already sexually mature, and catches practically no kanduli with eggs, since these evidently do not feed during the period when the eggs are held in the mouth.

The sakag both near the shore or in deep water is primarily for catching ayongin, but many times large quantities of very young kanduli are also caught.

The dala, or casting net, catches kanduli of all sizes besides other fishes, and may also take kanduli with eggs.

The other fishing methods of minor importance need not be discussed since they do not catch either the young kanduli or those with eggs. But the *tilay* should receive special attention in this connection since while it catches only large kanduli, it uses very young kanduli for bait. As the baits so used cannot be of any considerable number, that is, speaking in relation to the kanduli fishery as a whole, the use of undersized kanduli for bait for this particular fishing should be allowed.

DISCUSSION OF REGULATING MEASURES FOR PROTECTION OF THE FISHERY

In discussing the measures to be adopted for the protection of the kanduli fishery, there are several considerations which should be borne in mind. The fishery would certainly be depleted in due time with the increase in fishing activities around Laguna de Bay if they were allowed to go on unrestricted; but in adopting protective measures, these should not be to the extent of paralyzing fishing, unless it is shown that kanduli has been depleted to an extent that justifies extreme measures. Laguna de Bay naturally can support only a certain number of kanduli and protective measures that would permit the fish full liberty to breed at all times to the prejudice of fishing activities would be nothing but deliberate waste, since fostering such a number that cannot be naturally accommodated in the lake

would simply result in high mortality at the young stage. It would be wiser to catch the old fish and give more room for the young ones. Finally, the measure adopted must be effective. Certainly it would be difficult to find a happy medium among these considerations, but it is the only justified course.

The first remedy which readily suggests itself is the regulation of the size of the mesh of the nets and the distance between the slats of the corrals. This is not likely to be so effective. At present the interval between the slats of the corrals and the size of the mesh of the pukot, except the bag, are larger than the smallest kanduli which are caught. The small fish are caught apparently because they do not have the tendency of the other fish to go through spaces where they can, but simply continue moving around until they are unnecessarily disturbed when they force their way to escape. It is evident, therefore, that the problem does not consist so much in increasing the size of the mesh of the nets and the distance between the slats of the corrals since the young kanduli are likely to stay inside these gears in any event, but in giving the young fish a chance to escape immediately after they are caught. A delay in putting the young fish back into the water may kill them.

To allow the young fish to escape, the mesh of the bag of the pukot might be widened to the extent which would allow fish of certain size to go through. In the case of the corrals, the owner may have a small bag net, with the right-sized mesh, placed in the water but with the mouth high above the surface. Into this bag he can dump his catch as he is taking it out of the corral. Then, when he is through he can lift the bag out of the water into his banca ready for home or market.

The other fishing gear concerned is the sakag. The main catch of this is *ayoŋgin*, which is a surface fish, and since kanduli stays mainly below the surface, operators of this gear have learned to separate the former from the latter while lifting it above the water. The question, therefore, of allowing the young kanduli to escape does not present any special problem, since by taking the *ayoŋgin* first he can throw away the young kanduli or the process may be reversed as desired by the operator.

The next question involved is the size of the mesh of the pukot bag and the suggested corral owner's bag. In order to decide this point measurements of the length and greatest circumference of the body of a series of different sizes of kanduli were made.

The data are given in the following table.

TABLE 1.—*Showing the greatest circumference of the body of kanduli of different sizes. Measurement from tip of snout to tip of tail fin.*

No.	Length.	Greatest circumference around the body.	Remarks.
	<i>mm.</i>	<i>mm.</i>	
1-----	57	29.5	Measurement is around the shoulder girdle, passing through its widest expansion at the base of the pectoral fins. The part of the kanduli around which the measurement is made is inflexible.
2-----	91	44.0	
3-----	105	50.0	
4-----	127	62.0	
5-----	138	71.5	
6-----	157	74.0	
7-----	193	96.0	
8-----	208	113.5	
9-----	265	128.5	
10-----	308	160.0	

Published data show a minimum length of 135 millimeters measured from the snout to the end of the caudal vertebræ, for kanduli with maturing eggs. This size would be about equal to that of No. 6 in the table. Taking this as the maximum size of the fish which should be allowed to escape, the mesh of the pukot bag and corral owner's bag should be a little over 37 millimeters stretched. A mesh of 40 millimeters stretched should give a very good chance for kanduli of the size mentioned and even a little bigger, say 160 millimeters, to get away.

The next regulation measure is the prohibition of fishing during the spawning season. This would certainly be the most effective protection, so much so as practically to keep the kanduli unmolested in Laguna de Bay all the time. As has already been stated, the spawning season lasts from February to May and the brooding period lasts about two months, so that if the lake is going to be closed to fishing, the closed season must be from February to July. The important fishing gears which would be affected are the pukot, pante, corrals, kitang, and dala. As a general rule pukot and pante are not in operation during the rainy season, that is from June to November or December, because the nets cannot be dried during the rainy season and because of the heavy wind which is prevalent during these months. In other words, if kanduli fishing were prohibited from February to July on account of the rain and the wind, and the important net gears were inoperative from June

to November or December, the actual fishing season would only be in January or possibly as early as December. This would be equivalent to entirely prohibiting the fishing of kanduli by these methods, since people are not likely to make investments in nets if they can use them for only one or two months during the year. It is, however, true that there are pukot and pante, especially the latter, which are operated even during rainy days, and there are days in August, November, and December when fishing with pante is easily carried on, it being sufficiently sunny for the smaller nets to be dried.

The case of fish corrals has already been discussed and since this gear catches very few kanduli with eggs it may be exempted from the closed season provided the precaution already discussed is observed. Since the kitang catches neither small kanduli nor kanduli eggs, it can be exempted from all regulations.

The next measure to be considered is the closing of a part of the lake to fishing during the breeding season. The kanduli are known to breed in the deeps of the lake. There are several of these deeps, one in each lobe and one in the southern section. It would seem that by closing each section in rotation, the object of maintaining the supply would be accomplished since a large number would be allowed to breed uninterruptedly. There are two serious objections to this, however. It would be rather difficult to enforce and it would be hard and unjust to those who happen to live in the section of the lake where fishing is banned.

The second objection is readily evident. Since practically all the fishermen in the lake are engaged in fishing for kanduli in one way or another, the fishermen in a section that happened to be closed would be in a difficult position. They might try to go to other sections, but this is not readily accomplished for it takes a great deal of time to reach other sections in a banca rowed by one man and, when the wind is blowing hard, this is decidedly risky.

That some fishermen would be forced to go to other sections may be expected, and this would take into consideration the question of enforcement. Will fishermen caught sailing or rowing with their fishing gears in a closed section of the lake be arrested? If so, this would be equivalent to prohibiting these people from fishing in the open sections, since they have no other way of reaching the place where fishing is allowed. If they were allowed to row over the banned area on the pretext of being on their way to another section that is open to

fishing, why cannot a fisherman with his gear ready just drop it in the water as soon as he is out of sight. Since it would be a practical impossibility to follow every fisherman who might be found in a closed section, the real object of the regulation would not be attained at all.

The drawing of an imaginary line to separate a closed section from an open one would doubtless be a constant source of dispute. How can a fisherman tell whether he is on the right or wrong side of this imaginary line? How can an officer of the law prove that a man is fishing within the prohibited ground when he is near or just at this imaginary line?

The fourth measure to be considered is the closing of the fishing activity during part of the spawning season. Probably the best part of the spawning season in which to prohibit fishing is May. All eggs laid during this season can have an undisturbed brooding period in the mouths of the males by extending the closed season through June and July.

The regulation should cover all gears in which spawning kanduli and kanduli with eggs in the mouth are among the principal fish caught. At present this would include the pukot, pante, and dala. Since in May, June, and July, practically all kinds of fishing methods are doing well, and since in these months rice planting is going on actively in many parts around the lake no fishermen would find it hard to earn his living in spite of the closed season for catching kanduli. The pukot will have to lay off anyhow in June and July on account of the rain which makes it hard to dry the nets and also on account of the wind. Pukot, therefore, is in reality forced to lay off only in May. Pukot owners should welcome the closed season in spite of the little sacrifice which they are required to make since it is for the maintenance of their own business. The fishermen attached to the pukot can easily turn to other kinds of fishing or to planting rice. What has been said may be said also of the pante. Dala, since there are not many people engaged in this kind of fishing, need not be dealt with to any extent. Suffice it to say that the dala fishermen can readily go to other kinds of activities in the lake or in rice fields.

To summarize, a law or order for the protection of the kanduli fishery should provide for the following points:

1. The catching, selling or buying, or in any way being in possession of kanduli of 160 millimeters length measured from the tip of the snout to the tip of the tail fin should be

prohibited. Fishermen using hooks (*tilay*), however, should be allowed to use very young kanduli for baits.

2. The mesh of the pukot bag should not be less than 40 millimeters stretched.

3. The corral fishermen should provide themselves with a bag of ample diameter and depth to hold the ordinary catch without crowding to an extent that would prevent the escape of young kanduli. The mesh of this bag should be no less than 40 millimeters stretched.

4. Fishing in the lake with an apparatus by the nature of which kanduli with eggs are among the principal ones caught should be prohibited from May 1 to August 1. This should include for the present the pukot, the pante, and the dala.

A question which may now be asked is whether the insurance of the breeding and brooding during May, June, and July, and the prevention of the catching of certain sizes would be enough to replenish the kanduli which have disappeared from the lake during the current fishing year and gradually to restore the quantity which may have been depleted during the past years. This is very hard to answer directly since very little is known about the habits and life history of kanduli, and the quantity caught yearly. The question may, however, be answered from general experience. The fact that it has not been possible for fishermen to state definitely whether there is such depletion at all shows that it cannot be very much. Now, allowing kanduli to breed and brood undisturbed for part of the time and preventing the catching of a certain size would certainly mean increasing by so much the replacement which went on before the regulation measures were put into effect.

As already stated, the finding of the happy medium between all the considerations given above would be hard, but the recommended regulation is, certainly, an approach toward that point. In order to determine more definitely whether the measure is adequate, the kanduli fishery should be studied biologically as well as statistically. In this way a continuous study of the subject will show whether or not the measure needs modification or even abandonment for a better one.

THE DALAG FISHERY OF LAGUNA DE BAY

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TWO PLATES AND ONE TEXT FIGURE

INTRODUCTION

This investigation was undertaken in order to determine in what way the important dalag fishery of Laguna de Bay may best be regulated, to the end that the supply in the future may not be unduly diminished. The time available for actual observations was short. Naturally the information obtained is more or less fragmentary, but with careful consideration it has been found sufficient to serve as a basis for definite recommendations. Furthermore, the data gathered show many problems in the dalag fishery that may be investigated intensively for the benefit of the industry.

Information was gathered in two ways—by talking to fishermen of good standing, and by direct personal observations. Statements by fishermen in one locality were carefully checked against statements in other localities and wherever and whenever possible, by personal observation. Particular care has been taken to observe the breeding habits of dalag, and the methods of catching this fish have been closely studied. Practically the entire coast of Laguna de Bay was visited and a great deal of time was spent on the lake, with fishermen or in a separate boat, observing the operation of the fishing apparatus both during the day and at night.

DESCRIPTION OF LAGUNA DE BAY

Laguna de Bay ¹ has an area of 930.7 square kilometers, excluding Talim Island. The outline is very irregular, the northern side being cut into three lobes by the mountainous Jalajala Peninsula and Binangonan Peninsula with its southern continuation in Talim Island. This irregularity in outline increases considerably the shoreline of the lake. The direct bearing of this fact on

¹ Philip. Journ. Sci. § A 11 (1916) 223-226.

the dalag population of the lake becomes evident when it is stated that this fish lives in shallow water near the coast. Numerous streams drain into the lake, which in turn drains through Pasig River into Manila Bay. There is a large area of muddy bottom extending along the eastern coast from Pila River to Santa Maria River. This section is the most valuable dalag fishing ground in the lake. During March and April the water is at its lowest, but rises rapidly when the season of heavy rains sets in, which is usually from June to August. Sometimes the water rises as much as 2 meters. Since the shore is low and the slope gradual around most of the perimeter, the area of the lake is increased very considerably during the rainy season, the addition consisting mainly of grass lands covered with water to a depth of from a few centimeters to 2 meters or more. This annual event has an important bearing on the breeding of dalag and on its food supply. In sections with muddy bottoms stationary vegetation such as *Vallisneria* and *Nelumbium* are present in water as deep as 2 meters or more, and in many shallower places a sedge, *Scirpus grossus* Linn. is dominant. The most-striking plant is the water hyacinth, *Eichornia crassipes* (Martius) Solms. It is met with all around the lake and being afloat it can be seen drifting across the lake, in patches of varying sizes, with every change in the direction of the wind. This is especially true during the rainy season, when it becomes a constant source of worry to the fisherman since it may carry away any fishing apparatus that he may happen to have set in the water at the time.

FISH CAUGHT IN LAGUNA DE BAY

Other kinds of fishes are caught in Laguna de Bay, but the closest rival of dalag in importance is the *kanduli*, a catfish of the family Ariidæ of which several species have been reported. Dalag, however, is considered the superior fish and hence is more expensive. The regions of the lake inhabited by these two kinds of fishes are quite distinct, the dalag confining itself to the shallower water near the coast and the *kanduli* to the deeper portions. Fishes of lesser importance include gobies, of which *biang puti*, *Glossogobius giurus* (Buchanan Hamilton) is the most valuable; *ayoñgin*, *Therapon argenteus* (Cuvier and Valenciennes); *talilong*, *Mugil* spp.; *palos Anguila* spp.; *buan-buan*, *Megalops cyprinoides* (Broussonet); *tagan*, *Pristis microdon* Latham; climbing perch, *Anabas testudineus* (Bloch); and *hito*, *Clarias batrachus* (Linnæus). The last two are included

with dalag in the popular term "mud fish," and are caught with dalag in some of the fishing apparatus. The large quantity of shrimps caught daily should also be mentioned here if for no other reason than that these crustaceans furnish a large portion of the dalag's daily food.

MARKETING OF DALAG

Dalag is marketed alive. Dead dalag is not much in favor and hardly sells. This is because when dalag is killed just before cooking it has a much finer flavor. Dalag, therefore, is kept in water until it is sold.

The largest dalag, varying in length from 50 to 55 centimeters, are considered standard market size in wholesale buying and selling and are known as *solo* (single).

Each fish of this size is counted as one; other smaller fish are counted as "two-equals-one," or "three-equals-two," etc. Fishermen and fish dealers do not look at the length solely in estimating the size, but also at the bulk of the body, and where the fish feed well the standard solo may, therefore, be shorter. This system has a very salutary effect upon the dalag fishery since it discourages the catching of the small fish.

DISTRIBUTION OF DALAG IN LAGUNA DE BAY

A very interesting phenomenon in connection with the distribution of dalag in Laguna de Bay is the fact that it is practically limited to the shallow water near the coast. This is strikingly demonstrated by observing the two fishing gears known as *pukot dalag* and *pukot laot* while they are in operation. The first, as its name implies, is for catching dalag and is cast in water about 2 meters deep. It also catches kanduli and other fishes. The other is designed to catch kanduli in the deeper regions of the lake and seldom catches any dalag. These two fishing gears are similar in general make-up but the former is the smaller.

There are three plausible explanations for the fact that dalag is limited to the shallow places near the coast. Plant growth must influence the distribution of dalag in at least two ways: First, shrimps are more plentiful among plant growth and since a good proportion of the dalag's food consists of shrimps, it is natural that it remains in this environment; second, the breeding habits of dalag, which will be dealt with in detail elsewhere, would also take it among these verdant surroundings. The third explanation, and possibly the most potent factor, is the

fact that it has to come to the surface to breathe, being unable evidently to maintain itself for any length of time with the oxygen dissolved in the water. Bubbles are released every time it comes up to breathe.

The frequency of coming to the surface is greater in the young dalag. The fry (*anak dalag*) that are already swimming freely come to the surface every few seconds. This accounts, at least partly, for the apparent and extraordinary activity of the fry, and for the many bubbles on the surface of the water which betray the presence of a swarm even at a distance (Plate 1, fig. 1).

Observations were made on two good-sized dalag in a well of water 2 meters deep to discover the frequency with which they came to the surface to breathe. The data are given in Table 1.

TABLE 1.—Showing the breathing intervals of two dalag. Observations made August 16, 1929.

Dalag 1; about 50 centimeters long (estimated).		Dalag 2; about 35 centimeters long (estimated).			
Time of breathing.	Interval.	Time of breathing.	Interval.	Time of breathing.	Interval.
a. m.	Min.	a. m.	Min.	a. m.	Min.
11.08:30.....		11.09:30.....		11.32:30.....	2½
11.12:30.....	4	11.13.....	3½	11.34:45.....	2½
(*)		11.14:30	1½	11.35:30.....	¾
11.21.....		11.17.....	2½	11.37:20.....	1½
11.23:30.....	2½	11.20.....	3	11.39:20.....	2
11.28.....	4½	11.21:30	1½		
11.30.....	2	11.23:30.....	2		
11.32:30.....	2½	11.25:30.....	2		
11.37.....	4½	11.28.....	2½		
11.39:20.....	2½	11.30.....	2		
Average.....	3½ ₁				2½

* Not observed.

The table shows that the larger dalag came to the surface to breathe on an average of every $3\frac{4}{1}$ minutes, and the smaller one, every $2\frac{1}{6}$ minutes. The intervals were very irregular, but this was evidently due to their being under observation. Oftentimes a fish would come to the surface to breathe but before accomplishing its purpose would sink to the bottom manifestly because it was frightened. Hence, the longer intervals which, however, are followed by much shorter ones. The average may, therefore, be taken as the normal frequency of breathing for these fish under these conditions.

It thus appears that in the deeper regions if dalag stayed at the bottom, where its principal food in the form of shrimps is mainly available, it would necessarily spend a great deal more time coming to the surface for air, leaving very short periods for "browsing" on the bottom. It is, therefore, necessary for dalag to stay in the shallower places near the coast where both food and air are readily available.

The distribution of dalag around the lake is general. Indeed, dalag fishing is a very important industry all over the populated coastal regions. There are, however, certain places where dalag are caught in very large quantities. A common characteristic of these places is a muddy bottom. Such localities are usually met with on coasts near river mouths and in indentations where the water is not disturbed. The most extensive and most valuable of these dalag fishing grounds is found along the eastern coast of Laguna de Bay, extending from Pila River on the south to Santa Maria River on the north. The most conspicuous feature of these places is abundant plant growth, mainly in the forms of *Nelumbium*, *Vallisneria*, *Chara*, and *Scirpus*, which find here a fertile medium for their development. This vegetation continually adds to the organic matter already present by constant growth and decay. Microscopic organisms naturally flourish and larger animals feed on these. Shrimps of the families Palæmonidæ and Atyidæ are present in large quantities and naturally attract the carnivorous dalag. These grassy places also present material for the nests of spawning dalag. The young fry, also, whose food must consist mainly of minute organisms, find here a rich feeding place, and this fact, in addition to the protection which standing vegetation affords the young swarms, must serve as a further inducement for the parents to deposit their eggs in these weedy surroundings. Thus, the relative distribution of dalag around the coast is greatly affected by the presence of vegetation which, in turn, requires a muddy bottom at reasonable depth for development.

A difference is noticeable in the distribution of the small and the large dalag. As has already been stated fry are very active and are found generally in shallow grassy places. They are limited in their habitation to the first few centimeter zones of the water, probably, as has already been explained, on account of their breathing habit, which brings them to the surface every few seconds. As they grow older and separate from the school they stay more at the bottom but still prefer the shallow water.

The large dalag are more sluggish in habit and prefer the bottoms of deeper places.

In the rainy season when the water has reached its highest level, dalag are present in large quantities in shallow grassy places and in rice paddies. As the water recedes, the large dalag, at least most of them, go back to the deeper water, while many of the younger dalag remain in ponds of water and in paddies until the isolation of these small bodies of water is complete and they are no longer able to get away. Here they are caught by fishermen with *salacab* or even with their bare hands (Plate 1, fig. 2).

Many young dalag are caught in these isolated ponds and paddies, but since they are too small to market they are seldom sold but are privately consumed. Most people seen following a harrow or draining small ponds are not professional fishermen. The question of whether this fishing should be controlled or not can readily be answered in the negative. If the fish are not caught, a large number of them will die after the pools dry up, which happens in most cases.

BREEDING HABITS

Spawning season.—Dalag spawn throughout the year. Especially is this true in rivers and regions where vegetation is plentiful, even during the dry season when the water level of the lake is at its lowest. But there are places during the hot months where the water recedes to a point where no vegetation is present, and here dalag seldom lay eggs until the water rises again. In these places people recognize a spawning season for dalag; but even in those sections of the lake where dalag lay eggs the year round, there is a season when spawning is more active. This takes place during different months in different parts of the lake. On the southern side the spawning begins about May and is very active during June and July when the water level has risen considerably. When the water is receding, dalag again lay eggs, although not so actively as during the rainy season. On the western shores, when the present observations were made during the latter half of July (1929), dalag eggs were not yet common. Fishermen stated that spawning was late because vegetation, mainly in the form of water hyacinth (*Eichornia*), was carried away to the opposite coasts by the wind and the water had not yet risen enough to cover the grassy portions of the shore. In the grassy region of the eastern side of the lake active spawning is said to start much earlier, being at

its height about March, April, and May; that is, during the dry season. However, it is known that egg laying goes on at all times, especially in *pugad-pugad*, an artificial nest used for trapping dalag, which can be seen floating in that section of the lake by the thousands during the dry months.

Mating of dalag.—It is generally known that the male dalag is smaller than the female. Indeed, there is a Tagalog phrase “magasawang dalag,” which refers to a human couple in which the husband is smaller than the wife. During the active spawning season, sexually mature dalag are caught in pairs in many fishing apparatus. Pugad-pugad owners welcome this time since it very often means two fish in the trap instead of one. However, fishermen who catch dalag by means of *bonbon* complain of this season because the catch is very often limited to two in each trap, whereas at other times there are many more. Dalag mates are jealous of their privacy and are known to drive away any intruder. Hence, even in a large bonbon, when it is occupied by a dalag pair of good size, no others are permitted to take shelter there. This claim was verified by actual observation.

TABLE 2.—Showing the number and size of dalag caught in each bonbon. Observations made June 20. Measurements in centimeters from head to tip of tail fin.

No. of bonbon.	Number of dalag in the bonbon.	Length of dalag.	Sex.
		<i>cm.</i>	
I.....	2	45	Male.
		48	Female.
II.....	2	43	Male.
		47	Female.
		22	Unrecognizable.
III.....	4	33	Do.
		34	Male.
		37	Female.
IV.....	2	31	Male.
		33	Female.
		22	Unrecognizable.
V.....	4	28	Do.
		33	Male.
		37	Female.

Bonbons I, II, and IV show plainly enough the correctness of the assertion. In bonbons III and V the fisherman, before closing the baclad which surrounds the bonbon, took his com-

panion to drive the fish from the surrounding region into the bonbons by beating the grass and the water. He believed that the small ones caught in III and V were not originally there but were driven into them.

Building the nest.—It is very well known that dalag construct a sort of nest. Usually a more or less grassy place is chosen with water ordinarily from 30 to 100 centimeters deep. The nesting dalag vigorously beats the grass with its tail clearing a space about 30 centimeters in diameter. The grass growing in the middle is bitten off and arranged around the sides.

Dalag is not readily inclined to lay eggs in water without any vegetation. In a well where the water was about 1.5 meters deep and where there was no vegetation available, it was observed that pieces of green banana leaves which had fallen into the well were bitten and otherwise torn to pieces and arranged rudely around a space where eggs were laid by an imprisoned dalag. The writer has been told, however, that cases have been known of imprisoned dalag laying eggs without any nest in a well where no material was available for its construction. Such cases, however, must be rare, and to encourage spawning grassy surroundings are necessary.

Eggs are not laid immediately after the nest is constructed. A newly constructed nest without eggs is an assurance to the fisherman that the female is soon coming to lay, and he, therefore, sets his trap for her. This fact opens the question of whether or not it is the male that constructs the nest, as is the case with many other fresh-water fishes. The general impression is that it is the female, but fishermen of long experience in catching nesting dalag state that it is the male. This agrees with published information that "oviposition is provided for in a rude receptacle which is prepared by the male."²

Laying of eggs.—The eggs of dalag float in the water. The general opinion is that during the act of extrusion the position of the dalag is with the abdomen up. Information from various fishermen who live in different places around the lake and who claim to have seen dalag actually laying eggs sustains the general belief. Some fishermen, however, assert that the laying dalag lies on its back at the bottom, while others claim it is on or near the surface, so that the spurting of the eggs is visi-

² Gill, Theodore, Parental care among fresh-water fishes, Ann. Report Smithsonian Inst. (1905) 403-531.

ble. It is probable that in the shallows the fish appears to be lying on the bottom, while in deeper water it seems nearer the surface.

Not all the eggs are laid at one time. This is easily proven by the fact that a dalag caught after laying eggs still has eggs in the body. The general opinion is that the dalag breeds twice a year.

Hatching of the eggs.—The eggs are hatched in two to four days, but not all at the same time, and a good proportion of them do not develop young at all. Those that fail to hatch have a whitish appearance. There is a general belief that when the parents are caught the eggs fail to hatch. There may be some truth to this assertion since the eggs are then deprived of the necessary protection from other fishes.

Number of young.—The number of young varies with the size of the mother. In the larval stage, the young move in a compact mass, which makes it possible to estimate approximately their number. In one large school, the occupied area, roughly measured, was 40 by 50 centimeters. It was estimated that the number of larvæ in a square centimeter would average no less than five. Therefore, the number of larvæ in this particular school was not less than 10,000. In a school of advanced fry an estimate of the number is not so easily made, since they are moving briskly and the formation is not compact. The larger the fry, the greater their tendency to separate from each other. Attempts were made to catch a number of schools of advanced fry with a salap, but in each case only part of the school was caught. In one large swarm of fry varying from about 45 to 65 centimeters in length about 2,000 were caught, and it was estimated that this number was about half of the total. The number in the whole may, therefore, be placed at 4,000. If it is considered that this number is the remnant of the large school of larvæ given above some idea may be had of the number which survives to the stage when the fry leave the parent.

Care of the young.—From the time the eggs are laid until the fry are big enough to take care of themselves, they are closely guarded by one of the parents, and apparently in some cases by both. That this is the case is readily observed. By closely watching the spot occupied by the eggs or a swarm of fry, the movement of the water and standing plant growth betrays the presence of a dalag under them, and in clear water

it can be seen following the school wherever it goes. Cases are said to be known of carabao jumping suddenly as a result of the bite inflicted by a parent dalag when this quadruped happened to step into its nest.

Whether it is the parent or the fry school looking for food which determines the direction of drifting is hard to tell. In the case of a parentless school, probably about a month old, it was observed many times that there was apparently no definite direction in its movement, but whenever it came to a place where food was plentiful, as may be judged from floating materials, the fry gathered around for some time to enjoy feeding. That a parent can lead a school of fry seems to be shown by the following incident: A school of about 10,000 week-old fry was inclosed in a corral of *sinamay* reënforced by being placed between two baclad with the necessary stakes. The inclosure was about 3 meters in diameter. The object was to study the rate of growth of the fry under as nearly natural conditions as possible. The fry were so small that they could slip through the mesh easily, but no finer *sinamay* was available. Under ordinary conditions the school stays in the same spot day after day, and this was verified by the behavior of this particular school, which the writer visited every day or two. From observation of other schools, this one would not be ready to leave the resting place for several days. By that time the fry would be too big to go through the mesh of the *sinamay*. Before the setting up of the inclosure, the parent dalag had been with the school. When the inclosure was made, however, the parent was left outside. The next morning the inclosure was in the same condition as the day before, but all the fry were gone!

The care given by the parent dalag to the eggs and fry is very well known to the fisherman. During the spawning season, therefore, he goes out to look for eggs or schools and then captures the guardian with his gear of various kinds. This is discussed more fully elsewhere.

While the dalag is ready to protect its young against intruders, under adverse circumstances it is apparently ready to eat its offspring, also. Fishermen are unanimous in their claim that the parent eats the fry, and say that they have actually seen parent dalag grabbing at the young with their mouths. While there is hardly any question of the veracity of a statement in which there is practically universal agreement, still it should be remembered that the parent dalag cannot voraciously and habitually eat its young since a large number of the fry grow to

maturity. Probably it sometimes happens that when the parent on guard cannot find food, it is forced to kill the pangs of hunger by eating a few of its progeny.

GROWTH OF THE YOUNG

As far as the writer is aware, in the Philippines the growth of dalag fry from the time they hatch until they leave the parent and separate from the school has not been determined. It is of special interest in connection with the object of this investigation that this particular phase of the growth of dalag be studied. Special effort was, therefore, taken to carry out this study as nearly as possible under natural conditions.

A number of schools were located and samples of fry taken at different times for measurement. It was not possible to study the growth of the fry from a single school since after a certain age the school leaves the original nest and keeps on the move constantly. There are also other factors that make it hard to follow a school, chief of which is the occasional flooding of the breeding places by rains. However, by comparing the growth of fry of different sizes from different schools it was possible to obtain a very good idea of the rate of growth of fry to the time they leave the parent. Table 3 gives the result of this study.

TABLE 3.—*Comparison of rates of growth of dalag fry before leaving the parent.*

Swarm No.	Date samples were taken.	Length.	Number averaged.	Growth by difference.	Remarks.
		<i>mm.</i>			
II-----	July 19	4.7	10	-----	
	July 22	6.5	10	1.8	
	July 24	8.1	10	1.6	Carried away by water before next sampling.
VI-----	July 17	-----	-----	-----	Eggs laid.
	July 20	-----	-----	-----	Eggs hatched.
	July 22	5.1	10	-----	
	July 24	6.4	10	1.3	Carried away by water before next sampling.
VIII-----	Aug. 10	25.9	10	-----	
	Aug. 20	34.0	3	8.1	Carried away by flood before next sampling.
IX-----	Aug. 9	7.2	10	-----	Found in well
	Aug. 16	7.9	10	.7	
	Aug. 24	8.9	10	1.0	
	Sept. 23	50.1	4	41.2	
	Oct. 21	80.2	2	30.1	

In other schools it was possible to obtain only one sampling and, therefore, they were not included in the table.

As seen in the table the most nearly complete and longest record is that of No. IX which covered from August 9 to October 21. When this particular school was discovered the fry already averaged 7.2 millimeters in length. Judging from No. VI it is calculated that the fry were about 8 or 9 days old when the first sample was taken. The age of the fry which averaged 50.1 millimeters long on September 23 may, therefore, be placed at 54 days.

Dalag fry measuring from 50 to 65 millimeters still swim in schools. Small isolated dalag which the writer has caught or seen caught in various places measured about 70 millimeters in length. It may be considered, therefore, that fry leave the parent at about 2.5 months of age.

When over 20 millimeters long they are occasionally used for food, and when still larger they are employed as bait for kanduli in kitang (trawl line) in Laguna de Bay. It is when the fry are still in schools that they are so easily caught in quantities and are, therefore, tempting to fishermen. They are easily located, as has already been said, on account of the bubbling of the water which may be seen at some distance. It appears, therefore, that the most critical stage in the life history of dalag, the stage when they should be protected, is when the young are still in schools.

Variation in growth.—In a large number of individuals hatched at practically the same time, there will naturally be much variation in size as a result of variation in the rate of growth. The writer has observed many schools and has for some time thought that the different sizes observed were naturally distributed around a certain mean. On October 21, while visiting the school which had been under observation since August 9, it was noticed that the school had been divided strikingly into two distinct groups with respect to size, one group consisting of much smaller individuals than the other. The two that were caught, taken from each group, measured 61.5 and 99.0 millimeters long, an average of 80.2 millimeters (Table 3). The longitudinal dimension, however, does not show the difference so much as the comparative bulks would.

In this fact must lie the main explanation of the phenomenon observed in a dalag couple namely, that the female is larger

than the male. It is assumed that in dalag the female is naturally larger than the male, and that the difference is the result of the difference in the rate of growth. If this is so, then the individuals in a school should show a tendency to be naturally distributed around two means. In other words, there should be two peaks in the curve. The more advanced the growth of the fry, the more pronounced this tendency should be.

To test this proposition statistically, as large a number of the largest fry available in a school were caught and the length of each individual measured. The results are presented in Table 4 and in fig. 1.

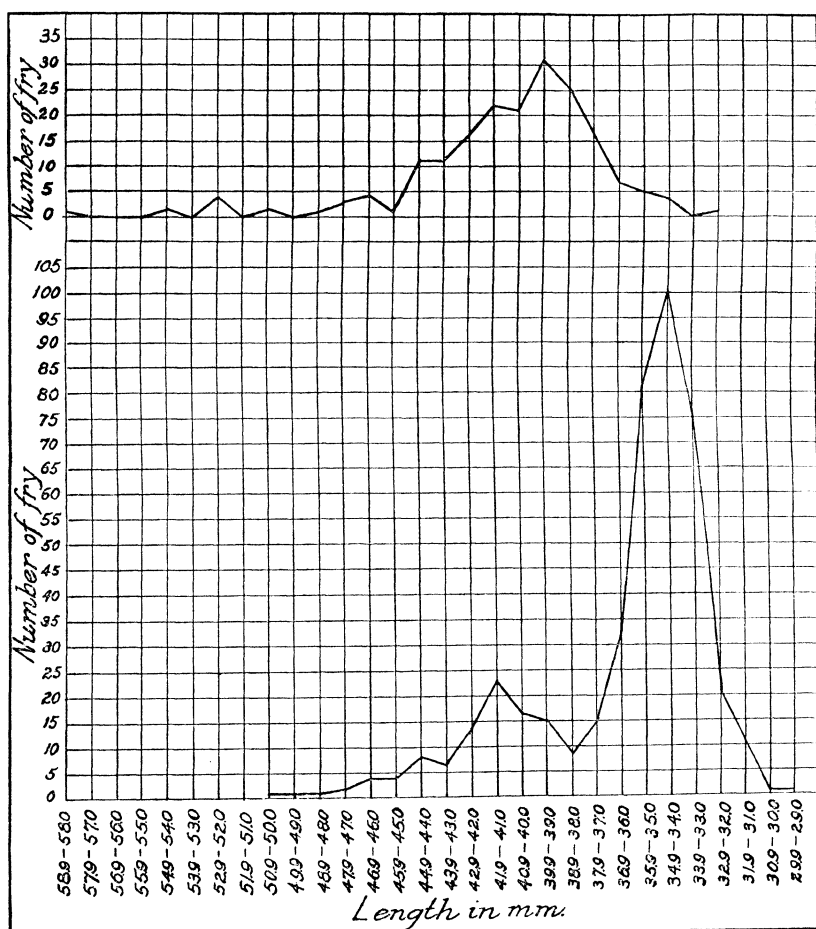


FIG. 1. Upper graph from data in Table 4; lower graph from data in Table 5.

TABLE 4.—Showing the distribution of the large fry with regard to size.

Length.	Number.	Length.	Number.	Length.	Number.
<i>mm.</i>		<i>mm.</i>		<i>mm.</i>	
58.9-58.0	1	49.9-49.0	0	40.9-40.0	22
57.9-57.0	0	48.9-48.0	1	39.9-38.0	33
56.9-56.0	0	47.9-47.0	3	38.9-38.0	31
55.9-55.0	0	46.9-46.0	4	37.9-37.0	17
54.9-54.0	2	45.9-45.0	2	36.9-36.0	7
53.9-53.0	0	44.9-44.0	11	35.9-35.0	6
52.9-52.0	4	43.9-43.0	11	34.9-34.0	3
51.9-51.0	0	42.9-42.0	17	33.9-33.0	0
50.9-50.0	1	41.9-41.0	22	32.9-32.0	1

This particular school was already well scattered, the fry being large and very shy. It was found very hard to catch them with the *salap*. Small ones were caught mostly; the larger, being energetic, easily got away. The data here given cannot, therefore, be considered as representative of the whole school. However, the curve is strongly askew on the left side as is to be expected, and there are groups of the larger size which would be hard to interpret except as indicating the formation of another peak if more of the larger ones had been caught.

In order to obtain a more representative population a school of smaller fry, and hence not so shy, was located. It was estimated that about one-half of the fry were caught. Table 5 gives the result of the measurements which have been graphed in fig. 1.

TABLE 5.—Showing the distribution of the small fry with regard to size.

Length.	Number.	Length.	Number.	Length.	Number.
<i>mm.</i>		<i>mm.</i>		<i>mm.</i>	
50.9-50.0	1	43.9-43.0	7	36.9-36.0	33
49.9-49.0	1	42.9-42.0	14	35.9-35.0	81
48.9-48.0	1	41.9-41.0	23	34.9-34.0	101
47.9-47.0	2	40.9-40.0	17	33.9-33.0	25
46.9-46.0	4	39.9-39.0	15	32.9-32.0	22
45.9-45.0	4	38.9-38.0	8	31.9-31.0	11
44.9-44.0	8	37.9-37.0	15	30.9-30.0	1
				29.9-29.0	1

It can be seen that the population is about twice the size of the first batch of fry and the curve presents a smoother appearance. The two peaks of the curve are plainly shown and as is

to be expected the first curve on the left is slightly skewed to the right, and the second slightly to the left.

AGE AND SIZE WHEN SEXUALLY MATURE

Fishermen in the lake are not definite as to at what age dalag matures. The general impression is that in one year it begins to bear eggs. The smallest female dalag seen during this observation, that carried mature eggs was 280 millimeters in length. From the rate of growth of the fry it is hard to estimate whether this size can be attained in a year. It should be stated, however, in this connection that availability of food has considerable influence on the rate of growth of dalag, and also that from the fry size to the sexually mature size, just mentioned, nothing whatever is known about the curve of the rate of growth to enable one to make a close guess. Herre³ states that dalag grown in his office became sexually mature in eighteen months when they may attain a length of 250 millimeters.

REGULATION MEASURES FOR THE PROTECTION OF THE DALAG FISHERY

There are several ways that readily suggest themselves by which the dalag fishery of Laguna de Bay may be protected. These are, (1) entirely prohibiting the catching of dalag during the spawning season, (2) prohibiting certain destructive fishing apparatus, or allowing their use only during a certain part of the year, and (3) prohibiting the catching of dalag of a certain size or at a certain period of its life history.

The prohibition of dalag fishing during the spawning season would seem at first thought to be the most effective. It has, however, been shown that in some parts of Laguna de Bay dalag spawn throughout the year. If a closed season for fishing is to be established, it must be for the part of the year during which spawning is most active. As has been mentioned before, there are two active spawning seasons that vary in different places and in reality overlap. When this fact is taken into consideration it will be seen that a law covering all the months when active spawning is going on somewhere in the lake, would prohibit fishing from March to November, leaving only three months open, but there is another important factor to be taken into account; namely, the period when the fry remain together in a

³ Philip. Journ. Sci. 24 (1924) 690.

school. The importance of protecting dalag fry at this stage has already been discussed. This period covers about ten weeks. In order to protect the fry that are hatched in November, the closed season would have to be extended to February. In other words, fishing would be entirely stopped. Thus, the closed season idea would defeat its own object, which is to protect the fishery for the benefit of fishermen and consumers.

The next measure to be considered is the absolute or partial prohibition of the use of all destructive fishing apparatus. This leads first to a discussion of all the fishing apparatus for catching dalag.

The methods of capturing dalag in Laguna de Bay are discussed in a separate paper, "Fishing Methods in Laguna de Bay." Here, however, it will be sufficient to consider those methods only with respect to their bearing on the conservation of the dalag fishery. The most important in this connection is the catching of the fry by the salap. This apparatus consists either of a net of fine mesh or of a sinamay cloth rigidly mounted on a circular or triangular frame and handled by one or two persons, depending on the size. As has already been said, the school of fry is first located and then scooped with the salap. In one operation from several hundred to one or two thousand young fish may be caught, though the bulk is small and only enough to satisfy a few persons at one meal. These are already good-sized fry and, if given a chance, a very large number should be expected to reach marketable size, but the salap is a legitimate apparatus for catching shrimps and fishes of different kinds, especially dulong, *Mirogobius lacustris* Herre. It would not, therefore, be fair to prohibit entirely the use of salap.

There are apparatus which take advantage of the nesting habit of dalag in their operation. *Loóng* is constructed to attract prospective laying dalag. When a dalag has laid her eggs in this hole, for that is what *loóng* essentially is, the fisherman waits for the parent which he knows is close by, with his *salacab*, or hook (*patucba* or *galay*, especially the latter). Most fishermen do not make *loóng* but hunt for dalag nests during the active spawning season. In this case, in addition to the fishing contraptions already cited, the rattan *bocatot* is also employed. The question presents itself as to whether these fishing methods should be regulated or entirely prohibited by law. The *loóng* is designed especially to attract laying dalag, and the rattan *bocatot* is made to catch dalag in the nest. The others are used for catching fish which are not laying. Practically all these

apparatus catch the parent dalag in the nest only after the eggs have been laid and hatched. The objection, therefore, to these fishing apparatus lies mainly in that the eggs and fry are deprived of the protection of the parent. Just how much destruction this means to the fry is very hard to estimate. But the writer has seen a large number of nests, with eggs, and schools in a place being daily ransacked by fishermen, and many of the schools must have been deprived of the protection of the parents, and yet the schools thrived. It appears, therefore, that the use of these apparatus is not objectionable, especially when it is considered that other fishing gears which catch non-spawning but sexually mature dalag do not even give the fish a chance to lay eggs. There are also other traps which should be considered in this connection; namely, the pugad-pugad and *pangloob*. These also attract nesting dalag. However, the eggs laid in these traps receive better protection than if they had been laid outside, and, therefore, the traps are rather an advantage.

The third measure to be dealt with is the prohibition of the catching of dalag of certain sizes, or at certain periods in their life history. It has already been stated that the system of marketing dalag discourages the catching of the small fish, but this applies only to the small individuals which have left the parents and separated from the school to live a more or less independent life. It has been shown that the most critical stage in the life history of dalag and the stage when they most need protection is when the young fry are still living in a school. At this stage the fry are known all around the lake as anak dalag. Their protection cannot be overemphasized. The catching of anak dalag by whatever means should be absolutely prohibited. When the regulation is properly enforced the dalag fishery will be adequately protected, at least for the present.

ILLUSTRATIONS

PLATE 1

FIG. 1. Bubbles created by a school of dalag fry.

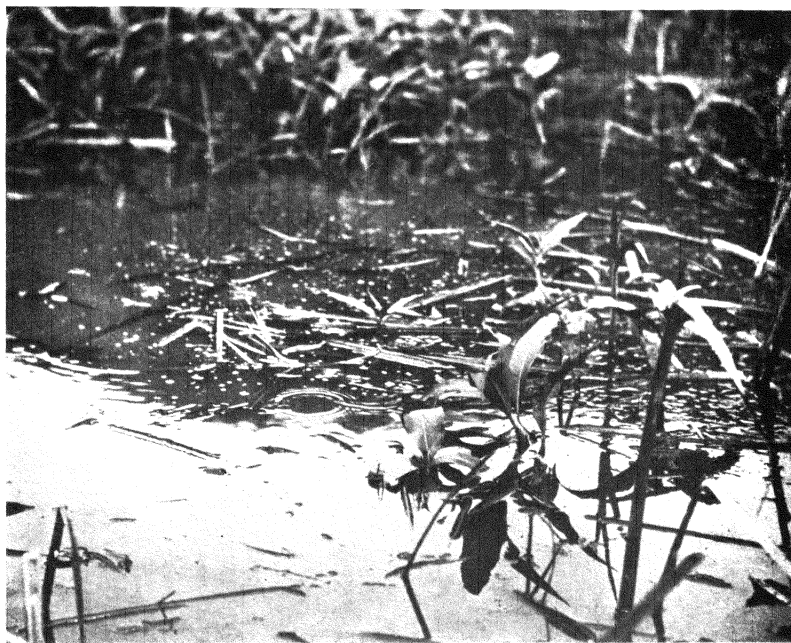
2. People fishing for dalag in a field that is being prepared for planting rice.

PLATE 2

Favorite spawning place for dalag. Nests are usually made in grassy indentations along the shore lines.

TEXT FIGURE

FIG. 1. Upper graph from data in Table 4, lower graph from data in Table 5.



1



2

PLATE 1.



PLATE 2.

THE IPON FISHERIES OF NORTHERN LUZON

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SIX PLATES AND SIX TEXT FIGURES

One of the most important industries of northern Luzon is the catching of *ipon*. Ipon is an Ilocano name for the fry of various species of gobies that spawn in the sea but spend most of their lives in the fresh-water streams of the interior. Gobies are small fishes, carnivorous bottom-dwellers living along the shores, lakes, rivers, and fresh-water swamps. Some cling to rocky places or gravelly bottoms where the current is very swift and where few other fishes are able to withstand the rush of the water. The adult gobies reach a length of from 8 to 25 centimeters and the young, when taken, are usually less than 3 centimeters in length (Plate 1, fig. 1).

From about June to August the adult gobies descend to the sea to spawn and during the period from September to March the ipon arrive near the coast of northern Luzon. They approach the shore in vast shoals with the incoming high tide about nine days after the first full moon of every month during the ipon season, and have been observed to linger for four or five days before they attempt to enter the streams. The ipon are then scaleless and whitish in color with tiny dark brown or blackish crossbars on the body; their eyes are black and prominent. Fishing begins along the coast in water from 1 to 10 meters deep as soon as swarms of ipon are sighted. The fish are caught during the day and during bright nights. At certain places in the river fishing usually lasts from three to four days of each month during the season, since the schools move upstream at different periods.

Ipon prefer to enter rivers having sandy or gravelly bottoms, clear water, and strong currents. When moving upstream they go in great schools, stopping among the rocks, stones, and sand to rest. It has been repeatedly observed that they travel in the daytime and during bright nights and stop to rest during dark

nights. The fish ascend very slowly, taking about twenty-four hours to cover the distance of 1 to 5 kilometers.

The ipon that enter the river in schools vary in size. The larger kinds usually stay at the bottom of the river and seldom come to the surface. The smaller ones are usually found on the surface and, being more active, often jump over the traps.

It is generally conceded by the Ilocanos that there is no finer table fish than the ipon caught in salt water. Their flavor is delicate, wholesome, and much preferred by the natives. As soon as the ipon enter the river they become darker in color and acquire a bitter taste and are, therefore, not considered a delicacy. Practically all ipon are converted into *bagoong*; small quantities are prepared for the table in various ways, the commonest being *tamales* and *sinigang*.

Bagoong is prepared by mixing two parts of ipon with one part of salt; sometimes the proportion is three parts of fish to one part of salt by bulk. Ilocano salt is usually used. The mixture is placed in earthenware jars, well covered to exclude flies and dirt. It is allowed to ferment for about a month or longer. If well made, bagoong is a clean, wholesome article of diet.

Tamales are prepared by wrapping fresh ipon with banana leaves, and then boiling in water containing vinegar and salt. Sinigang is simply fresh ipon cooked in water with the addition of tomatoes and salt.

The most important fishes constituting the supply of the industry are the following: Palileng, *Sicyopterus lacrymosus* Herre and *Ophiocara aporos* Bleeker, Plate 1, figs. 2 and 3; bal-la, *Glossogobius giurus* (Buchanan Hamilton) and *Glossogobius celebius* (Cuvier and Valenciennes), Plate 2, figs. 1 and 2; bucto and bunog, *Chonophorus melanocephalus* (Bleeker), Plate 2, fig. 3; virot, *Eleotris melanosoma* Bleeker, Plate 3, fig. 1; and campa, *Rhyacichthys aspro* (Kuhl and Van Hasselt), Plate 3, fig. 2.

FISHING METHODS USED

The principal appliances used in the commercial capture of ipon are nets and traps. The former are by far the more important, of which the seines and dip nets are the more widely used.

THE SEINE

The seine consists essentially of a long shallow strip of net with a buoyant headline and a weighted ground rope, and is

particularly adapted to shallow water on gradually shelving beaches.

A seine, varying in style and size, locally known as *daclis de ipon*, is used all along the shores of northern Luzon. It is made of sinamay cloth, 40 meters long, 3 meters wide at its widest portion, becoming narrower towards the end of each wing where it is about 2 meters wide, and is provided with a bag at the middle. The *daclis* is operated from the shore and used along the coast within 200 meters of the shore line. From fifty to one-hundred persons are required for its operation. It is also used in the mouth of the river where the water is about 3 to 10 meters in depth. During the ipon season a good haul will often bring in as many as 10 to 20 cavanés (1 cavané equals 75 liters) of fish, the usual haul being about 2 to 5 cavanés.

A new *daclis* of the size stated above, costing from 300 to 400 pesos, may belong to one person or several persons. The owners rent it to fishermen and the proceeds from the sale of the ipon caught are divided equally between the owners and the renters. One-third of the share of the owners goes to the persons who repair the net. One-third of the share received by the fishermen is given to those who pull the net to the shore. The annual license fee is based upon the size of the *daclis*. It is customary for the owners to deduct this fee from the sale of the first big catch of the season. In 1928 there were five *daclis* in use in Bangar.

The *daclis* used in the towns of Santa and Caoayan, Ilocos Sur Province, is similar to the one described above except the dimensions. It measures about 31 meters long, 4 meters deep along the middle, and 2 meters deep at the end of the wings. The bag is nearly 12 meters long. The net is of very fine mesh, too small for the fish to go through, there being eight meshes to the inch.

In 1928 there were no *daclis* used in the jurisdiction of the municipality of Aparri because a municipal ordinance exacted a tax of 200 pesos for each *daclis* per year. The exorbitant fee has discouraged the use of this important fishing apparatus which is claimed by the people of Aparri to be destructive to ipon fishing. As a matter of fact, although it is made of fine sinamay, it is not used all the time and its field of operation is limited because of the small size, being only about 40 meters in length.

The *garamgam* is a seine similar to the *daclis*, only smaller. From twenty-five to thirty persons are needed to operate it. It

is used both along the seashore and in the mouth of the river in the municipality of Bangar, La Union.

Both the daclis and the garamgam are tanned with the bark of trees, especially mangrove. If treated each year, the net will last from three to four seasons.

CAPUT

The *caput* is a kind of dip net, mounted on a triangular bamboo frame (Fig. 1). Each side of the net is about 2 meters long.

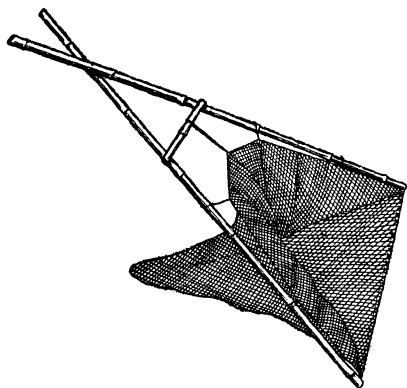


FIG. 1. Dip net, *caput*, used for catching ipon.

The netting is made of fine sinamay which is about 3 meters long and forms a long bag at the center. One man operates the *caput* by pushing and lifting it from time to time. It is used on sandy sea shores and in rivers. Being a small net, it catches but small quantities of fish and is practically useless when the ipon are scarce. It is not employed for commercial purposes, and what ipon are caught with it are kept for domestic consumption.

It is not a very effective gear, but is used all over the provinces of northern Luzon.

FISH TRAPS

In this region by far the greatest amount of marketed ipon is taken from the rivers in the more elaborate devices collectively known as traps. These are fixed structures which vary in construction and arrangement from the simple single-line dam across the stream to the more complex designs with series of barricades, blind canals, and pockets. The component parts consist of stone dams, bamboo fences, woven-bamboo matting (*sawali*), banana leaf-sheaths, dip nets, and bobos. There are no less than five types in use, which are all ingeniously devised with deadly purpose. They are built in the river beds during the dry season when the water is at its lowest. The most important of these traps are the *bobo*, *sarep*, *pingi*, *pamoboan* or *padait*, and *pamalibtocan* or *burayoc*, which are described and illustrated in the following paragraphs. It is well to point

out here that in all these styles the main idea is to lead the fish and snare them in the pockets which may be in the form of hoop-nets or bobos. Obviously the collecting receptacle is of the greatest importance in a trap.

Bobo.—The bobo (Fig. 2, and Plate 4, figs. 1 and 2) used with the above-mentioned devices is of a particular construction. It is made entirely of finely smoothed bamboo splints; in form it resembles closely a large bottle with a small short neck; it is 79 centimeters long and 26 centimeters in its greatest diameter, the opening at the end of the neck is about 7 centimeters in diameter. The catch is removed through this opening, which at other times is kept closed with a cork. At the other end is the mouth which is provided with a funnel with four openings, each 2.5 centimeters in diameter; behind this funnel is a secondary funnel 50.5 centimeters in total length, with a comparatively long tube 2.5 centimeters in diameter; this tube is in the same vertical line with the opening of the neck and its opened extremity is 9.5 centimeters from the cork.

Sarep.—The sarep is a row of bobos held in place at the bottom of a stream between bamboo piles driven about a foot apart. The mouth of the bobos is level with the ground and faces downstream purposely to catch the ipon swimming on the bottom against the current.

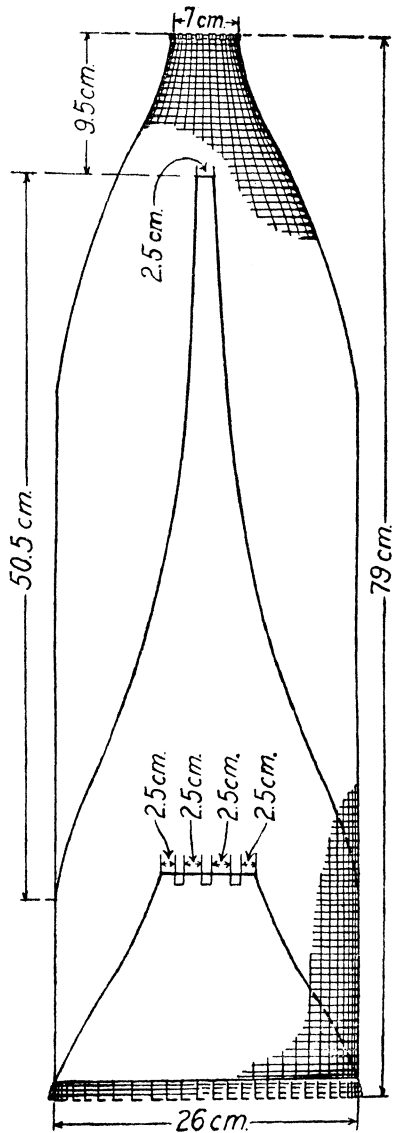


FIG. 2. Diagram of a bobo showing position of inside funnels.

This gear is generally set across a third of the river, although it is not infrequently found extending across the entire width of the channel. It is very effective in shallow water, about 1.5 meters deep, with a swift flow. The sarep is used only in Abra River in the vicinity of Caoayan and Santa, Ilocos Sur.

In Cagayan Province the device known as bobo is exactly like the sarep in construction, except that it is set close to the river banks, since Cagayan River is deep and wide with very strong currents.

Pingi.—In Ilocos Norte Province the river traps used for catching ipon are known locally as pingi. The construction of the pingi varies according to locality. The pingi near the coast is set in places where the water is about 2 feet deep. It is built in the following manner: Bamboo piles a little over a foot apart are driven across the width of the river, except a space of 12 meters in the middle. Between the bamboo posts, holes are dug to accommodate the bobos, the mouth of which should be level with the ground. These bobos are 92 centimeters long and 31 centimeters in diameter. The mouth is provided with a funnel with seven small holes, each 2 centimeters in diameter. At the top of the bobos a wall of sawali is constructed. The upper edge of the wall is slightly below the surface of the water; it is inclined a little with the direction of the current in order to make a waterfall. This prevents the fish from jumping over. Sometimes a small piece of white cloth is placed at the top of the wall to frighten the ipon, thus preventing them from jumping over the fish trap. Herewith is shown a sketch (fig. 3) of a pingi at Laoag River about 1 kilometer from the shore, (Plate 5, figs. 1 and 2, and Plate 6, fig. 1 show the setting and operation of this apparatus).

The pingi described below (fig. 4) was constructed in 1928 at the back of the municipal building of Sarrat, an interior town of Ilocos Norte. This may be considered a variation of the pamalibtocan, since the fundamental idea involved is the same.

The part of the trap marked D is built with stones topped with a wall of banana leaf-sheaths. C represents a canal about 16 centimeters wide and approximately 16 to 18 centimeters deep. B represents the bobos placed at the extremities of the canal C and at the ends of the barricades marked D_1 and D_2 . The bobos at D have their mouths downstream, and those at D_1 and D_2 face the current. D_5 represents a barricade built with stones and gravel along the bank of the river to make the surface stream narrower. D_6 and D_7 represent barricades built with

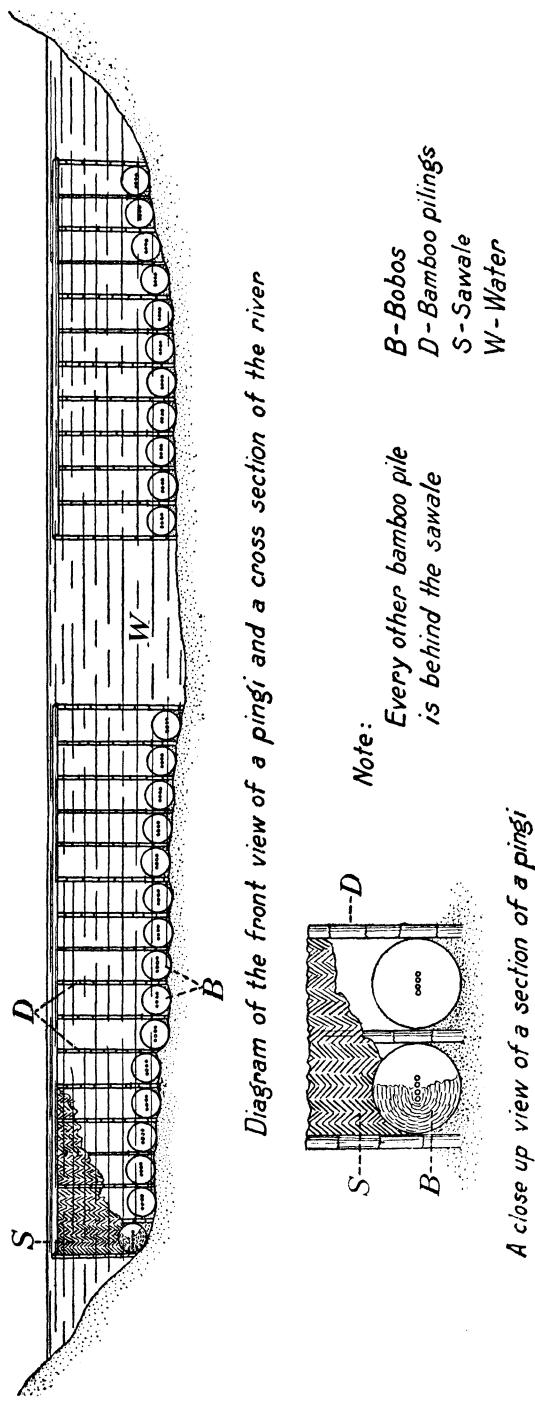


FIG. 3. Pinggi near the mouth of Laoag River.

the same materials used for D_5 , and high enough so that the water cannot overflow them. D_3 and D_4 represent dams built with big rocks and gravel. The top of the dam is from 3 to 5 centimeters below the water. The dams are so made as to increase the velocity of the current. This is an important factor since the ipon in going upstream prefer to swim against a strong flow. D_1 and D_2 are dams constructed in the same manner as those of D_3 and D_4 , but their top is above the water. At one end of the barricades a bobo is placed.

Pamoboan or *padait*.—In the interior of Amburayan, Abra, and Laoag Rivers where the water is not deep, the fishing device used is the pamoboan (in La Union) or padait (in Abra) (Fig. 5).

In the sketch D represents dams which are built with stones upon which is erected a wall made of banana leaf-sheaths. These sheaths are piled just high enough to let the water pass over and form a waterfall. D_1 represents dams constructed with gravel and big stones or rocks. They are built high enough to prevent the water from overflowing them. This part of the trap is designed to increase the current going to the parts of the dam indicated by D. B represents bobos placed at the extremities of the canal, shown by C. The canal is about 16 centimeters wide and 16 to 18 centimeters deep. The water in this canal is quiet and the ipon follow it only to be entrapped. N represents hoop-nets (*pataya*) made of sinamay about 60 centimeters in diameter, with a bag about 2 meters long. The hoop-nets are placed at the side of the fences or barricades, shown by F, in order to catch the ipon that are trying to return downstream. The pamoboan is a very destructive method. Along Abra River there are several lines of pamoboan catching ipon that have escaped the preceding inclosures and leaving very few to go further upstream.

Pamalibtocan or *burayoc*.—The pamalibtocan is a device consisting of bamboo fence, coco palm leaves, banana leaf-sheaths and hoop-nets. It is found to be effective only in shallow places where the water is about a meter deep. A sketch of a pamalibtocan in operation about a kilometer from the mouth of Amburayan River is here shown (Fig. 6). F represents a fence called *bayabay* which is constructed of coco palm leaves and bamboo. It is made practically water-tight, sufficiently strong to direct the current to one side and usually high enough to prevent

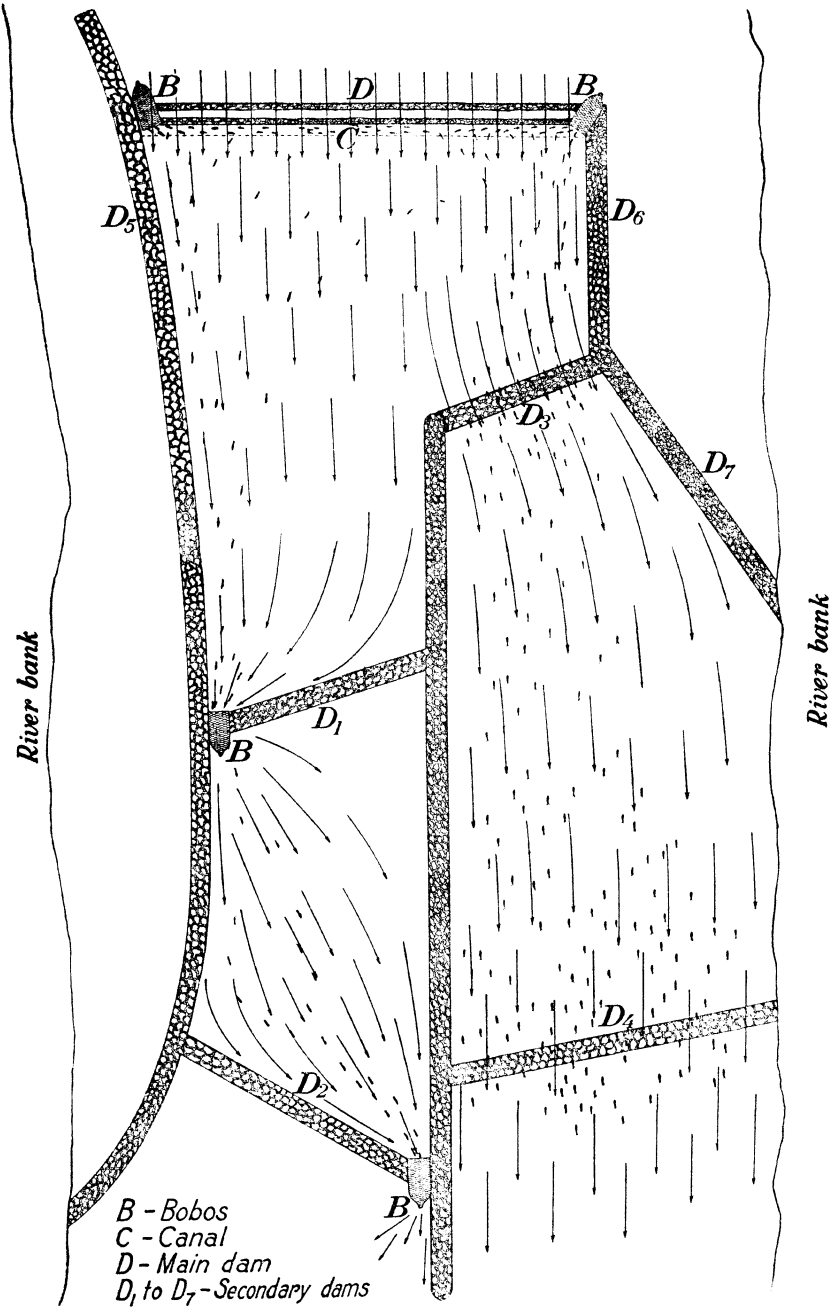


FIG. 4. Ipon trap, pingi, in the interior near Sarrat, Ilocos Norte.

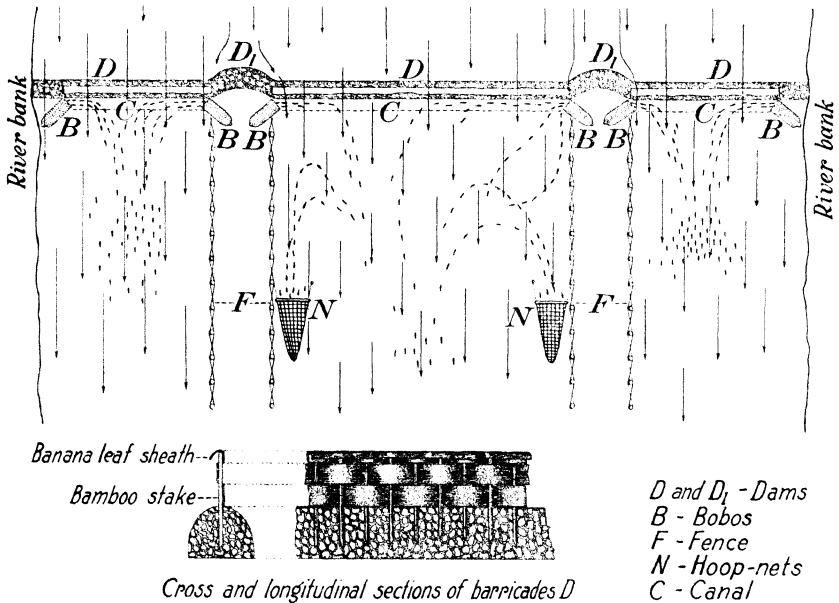


FIG. 5. Ipon trap, padait, near Bangued, Abra.

the water from overflowing it. It is from 8 to 10 meters long. D_1 represents a dam in the shape of an inverted V, made of stones, coco palm leaves and bamboo; the outer side upstream is reënforced with stones and earth; this side is about 3 to 4 meters long. The top of the fence is sufficiently exposed. The wedgelike obstructions increase the velocity of the flow of water over barricade D , indicated in the sketch. The strong current thus produced prevents the ipon from jumping over the banana-sheaths on top of the dam represented by D . In building a dam, the big stones are removed and the place is leveled and smoothed. Then bamboo piles are driven one foot apart. Good-sized stones and earth are piled to make the dike and upon this a wall of banana leaf-sheaths is erected. The last banana leaf-sheaths at the top are so placed as to produce a sort of waterfall with the current. Below the fall is a canal, represented by C . The water in this ditch is quiet, and it is by means of this blind alley that the small creatures are led into the traps. The curved banana leaf-sheaths by their movements and silvery appearance frighten the ipon, thereby preventing them from going over.

N shows hoop-nets placed at the ends of the canals where the ipon are led and trapped. B shows the bobos. These are set with the mouths on a level with the ground and facing the current and placed where the flow is very strong, for the ipon

usually go where the velocity of the water is greatest. F_1 shows a fence similarly constructed as F , made to guide the fish into the hoop-nets represented by N_1 . These hoop-nets are cone-shaped and made of sinamay, the bag of which is about 2 meters long, with a mouth 70 to 80 centimeters in diameter. The hoop or ring is made of bamboo.

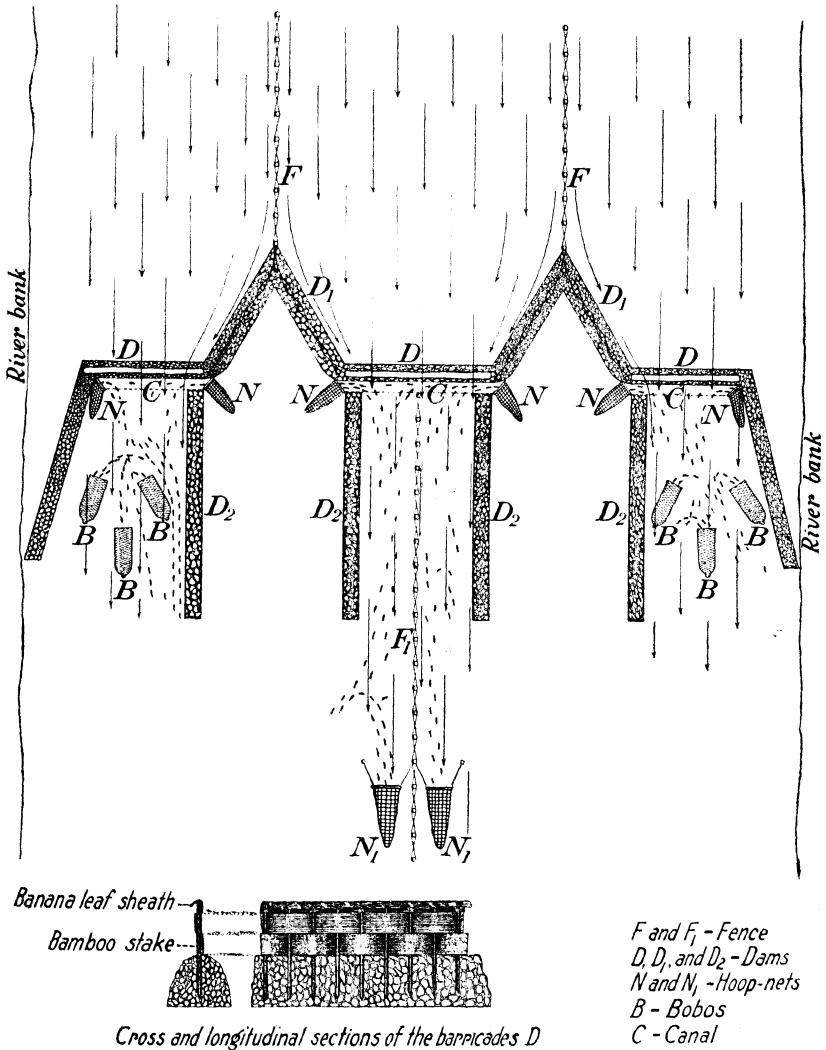


FIG. 6. Ipon trap, pamalibtocan, located about 1 kilometer from the mouth of Am-burayan River.

The pamalibtocan is a very effective device. Oftentimes it is placed across the whole width of the river, and when so set,

it allows but a few fish to escape. In certain localities it is not unusual to see several series of this trap damming the stream, so that the chances of the ipon to escape and to reach the headwaters are very slight indeed. (Plate 6, fig. 2 shows the setting of pamalibtocan at the Amburayan River.)

THE ECONOMIC IMPORTANCE OF IPON

In La Union Province, ipon are fished along the coast and in four rivers. Two of these rivers, the Aringay and the Ba-uang, are very narrow, and their mouths are sometimes completely closed, a condition which makes fishing uncertain and occasional, therefore unimportant. The other two rivers in which ipon abound are Bangar (also known as the Amburayan) and Baroro Rivers.

The portion along the mouth of Amburayan River coming under the jurisdiction of Bangar belonged formerly to Tagudin. There was for a long time a controversy between the two municipalities as to which should control the ipon fisheries in this section, but recently the controversy was decided in favor of Bangar. From this section, Paratong River, and the portion of the sea-coast which Bangar holds, more ipon are caught than from all other sources in the La Union Province. It has been estimated that in 1928 around 10,000 five-gallon petroleum cans (= 189,250 liters) of ipon were caught in Bangar. This quantity of fresh fish was valued at approximately 30,000 pesos. During the same year, in Baroro River and along the coast of Bacnotan the catch of ipon amounted to 1,000 five-gallon petroleum cans (= 18,925 liters), with an estimated value of about 6,000 pesos.

In Ilocos Sur Province ipon are being caught in great quantities in the Amburayan and the Abra. The former river was for many years the leading fishing center but lost its importance when it changed its course.

Near the mouth of Abra River are the towns of Caoayan and Santa, both noted for ipon fishing. In 1928, the fishery of Caoayan was valued at 18,000 pesos, that of Santa at 15,000 pesos. From fishery license fees collected for the year, the municipality of Caoayan received 2,200 pesos and the municipality of Santa, nearly 2,000 pesos.

The river fisheries of both Caoayan and Santa are divided into lots, which are disposed of at public auction. The municipalities do not prescribe the kind and number of fishing ap-

paratus to be used by the lessee. It is obvious then that under these conditions the fisheries are exploited, and it is feared that, unless the methods are regulated, the capacity of the species to keep up the natural supply may be taxed to the limit, with the result that the fisheries will be ruined through overfishing.

Ipon do not reach the town of Bangued, Abra, until about three weeks after the time they enter the mouth of Abra River. The fish are then about 2.5 to 4 centimeters long. The fishery in this province is not as important and lucrative as in La Union and Ilocos Sur. This can be seen from the following collections for 1928.

Town.	Income from fishing licenses. Pesos.
Bangued (capital of Abra)	5.45
Pidigan	7.00
San Quintin	98.65
Bucay	101.90
Total	213.00

In Ilocos Norte Province ipon fishing is done in Laoag River, but the fishery in the interior is not commercially important. The river passes through the towns of Laoag, San Nicolas, Sarrat, Dingras, Piddig, Solsona, Banna, and Nueva Era. During the rainy season, the river is about a kilometer wide and several meters deep, with a swift current, but in the dry season it is shallow and narrow.

There is, however, considerable fishing at the barrios of La Paz and Gabo, which are located at the mouth of the river and come within the jurisdiction of Laoag. This town has an ordinance which prohibits the setting of traps across the entire width of the river, and provides that there must be a distance of not less than 50 meters from one series of fish traps to the other. The ordinance is an excellent protective measure and Laoag complies with it, but in the interior towns there are no such ordinances for the protection of the ipon and the traps are oftentimes set across the entire width of the river.

From the mouth of Laoag River to the town of Laoag, a distance of about 6 kilometers, seventeen pingis were seen in operation. The ipon that are able to escape from the first pingi have little chance to escape the succeeding traps.

Ipon fishing is a very important industry in Cagayan Province, especially in Aparri, Abulug, and Buguey. The esti-

mated ipon catch of Aparri in 1928 was about 2,500 five-gallon petroleum cans (= 47,302.5 liters), valued at 6,250 pesos. The municipality received during the year an income of about 4,500 pesos from fishing licenses of all kinds. The corresponding catch in Abulug was 2,000 five-gallon petroleum cans (= 37,850 liters), worth around 5,000 pesos, and the licenses for apparatus and fishing rights amounted to almost 850 pesos.

CONSERVATION OF THE IPON FISHERIES

The term "conservation" has been greatly abused and often has become associated in the mind of various people, particularly the fishermen throughout northern Luzon, with oppressive restrictions upon their right of fishing. It is appropriate, therefore, to re-state the true meaning of the term. Conservation implies the fullest and wisest use of nature's wealth without endangering the supply for the future.

That the supply of ipon has been endangered could not be definitely ascertained, for lack of statistical data. But it has been noted that the methods for capture have increased in number, effectiveness, and destructiveness due to ingenuity of construction and operation. The catches are much more now than before and the demand has also become greater, incident to the increase in population.

A study of the existing conditions of the ipon fishery in the Ilocos provinces shows that the people in the interior are economically affected by the intensive fishing through the unregulated use of traps along the coast towns and at the lower courses of streams. Traps are destructive because they are so set as to cover the entire width of streams and as a consequence only a few ipon are able to go to the headwaters to reach maturity. Ipon enter the rivers, move slowly upstream whenever possible, and may approach the traps any time. Because of their slow movement, they may escape the first series of traps only to be caught in the succeeding inclosures.

In regulating the use of traps, a knowledge of their operation is essential. It takes some time to set the bobos properly and even much longer to replace them in position after their removal since the work is done in swift water. A good protective measure would be to leave the middle third of the river open for the free and unimpeded passage of the fish and to fix the distance between any two series of traps at not less than 150 meters. Unless a regulation of this kind is made, this important industry is doomed to perish.

ILLUSTRATIONS

PLATE 1

- FIG. 1. Ipon when caught near the mouth of the river; $\times$ 2.6.
2. *Sicyopterus lacrymosus* Herre. (Drawing by P. Bravo.)
3. *Ophiocara aporos* Bleeker. (Drawing by M. L. Nievera.)

PLATE 2

- FIG. 1. *Glossogobius giurus* (Buchanan Hamilton). (Drawing by M. L. Nievera.)
2. *Glossogobius celebius* (Cuvier and Valenciennes). (Drawing by P. Bravo.)
3. *Chonophorus melanocephalus* (Bleeker). (Drawing by P. Bravo.)

PLATE 3

- FIG. 1. *Eleotris melanosoma* Bleeker. (Drawing by J. Nievera.)
2. *Rhyacichthys aspro* (Kuhl and Van Hasselt). (Drawing by A. L. Canlas.)

PLATE 4

- FIG. 1. Bobo for catching ipon.
2. Mouth of bobo for catching ipon.

PLATE 5

- FIG. 1. Setting bobos to a pingi near the mouth of Laoag River.
2. Finishing a pingi near the mouth of Laoag River.

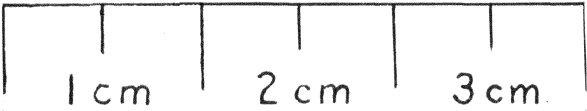
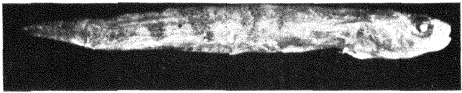
PLATE 6

- FIG. 1. Ipon trap, pingi, in operation near the mouth of Laoag River.
2. Setting pamalibtocan, about 1 kilometer from the mouth of Amburayan River.

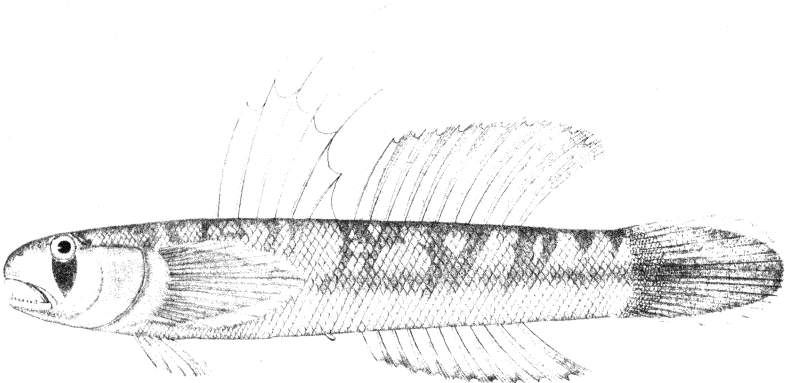
TEXT FIGURES

[Drawings by A. D. Verzosa.]

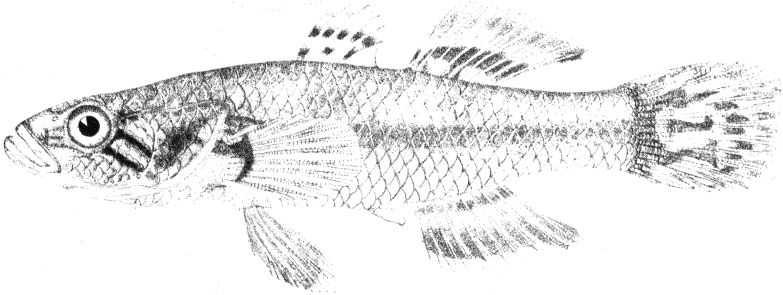
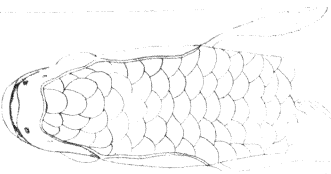
- FIG. 1. Dip net, caput, used for catching ipon.
2. Diagram of a bobo showing position of inside funnels.
3. Pingi near the mouth of Laoag River.
4. Ipon trap, pingi, in the interior near Sarrañ, Ilocos Norte.
5. Ipon trap, padait, near Bangued, Abra.
6. Ipon trap, pamalibtocan, located about 1 kilometer from the mouth of Amburayan River.



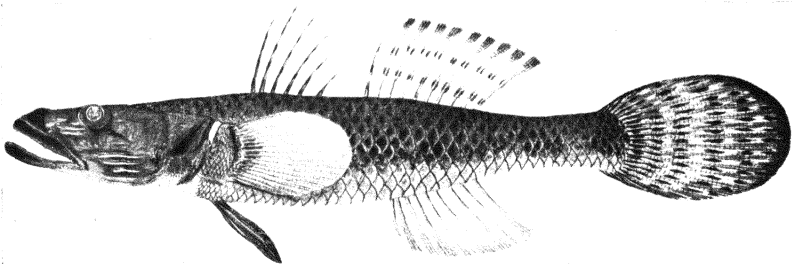
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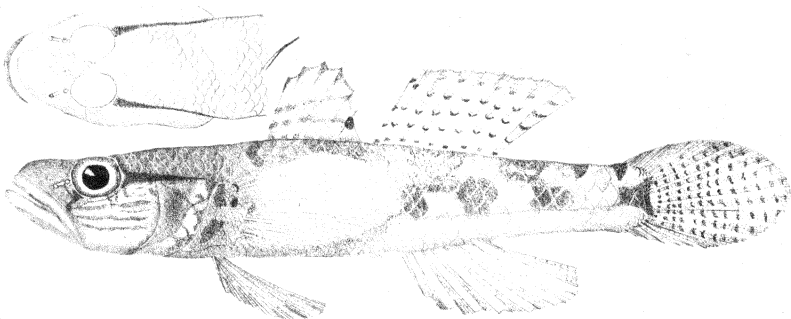
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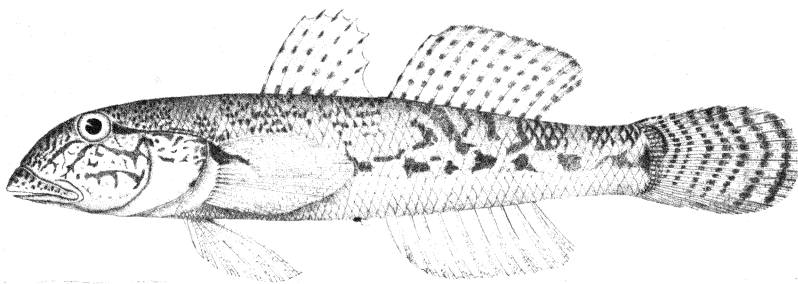
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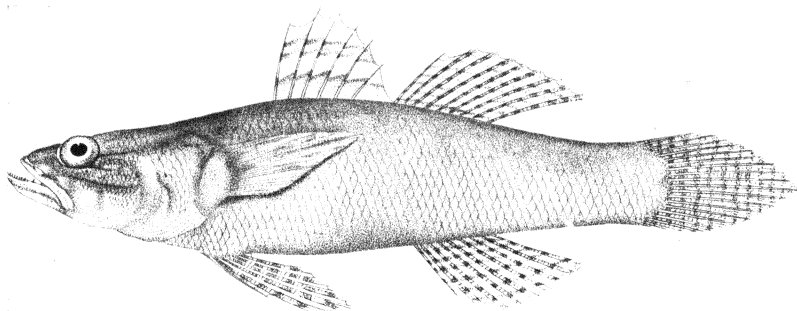
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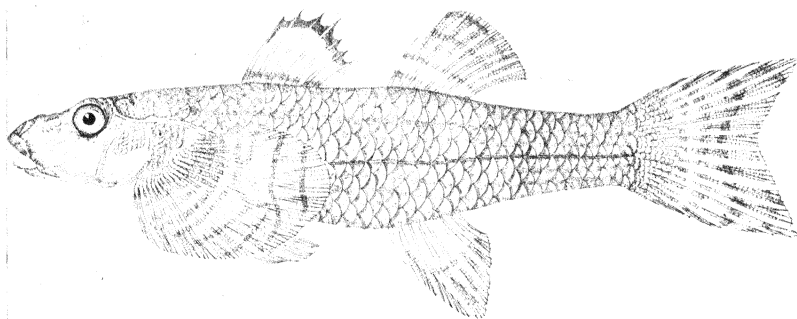
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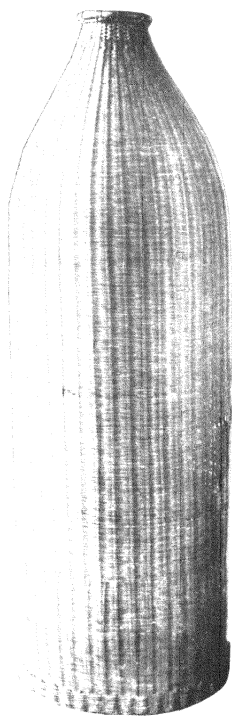
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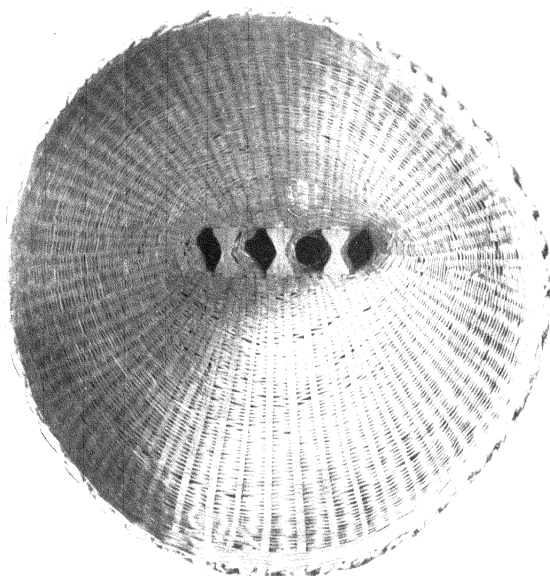
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LABORATORY TESTS ON THE DURABILITY OF PHILIPPINE WOODS AGAINST FUNGI

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and

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TWO PLATES

Our present knowledge of the durability of indigenous woods in tropical regions is for the most part limited to a few records of their life under service conditions. These records were taken mainly on railway ties or other structural timbers in contact with the soil. An occasional investigator has carried on laboratory tests, but the woods examined in this way have been comparatively few.

During the period 1919-21 Reinking published a series of five papers¹ listing a considerable number of Philippine wood-destroying fungi and their hosts, the fungi being determined by Patouillard and Lloyd. While these articles do not exhaust the subject by any means, they offer a first modest attempt at recording some of the host relationships of the commoner fungi found on structural wood and timber in the forest.

While decay is but one factor in the destruction of timber, it is, nevertheless, a highly important one, for in the moister parts of the Tropics, with their comparatively high temperature and long growing season, a particularly favorable environment is offered for the development of wood-destroying fungi.

Durability tests in the laboratory offer the advantages of rapid and severe exposure under more or less controlled conditions and of direct comparison of the relative resistance of the materials to the fungi used.

In 1915 Humphrey² tested the heartwood and sapwood of greenheart (*Nectandra rodiaei*) against twenty-six species of the commoner fungi prevalent in the United States. Blocks $\frac{5}{8}$ by $\frac{5}{8}$ by 2 inches were partially embedded in sand in test tubes and surrounded by culture blocks of spruce or beech, with sphagnum above. At the end of a year the heartwood blocks were

¹ Philip. Journ. Sci. 15 (1919) 479-490; 16 (1920) 167-179, 527-537; 17 (1920) 363-374; 19 (1921) 91-114.

² Mycologia 7 (July 1915) 204-209.

slightly decayed by ten of the fungi, with a maximum loss in weight of 3.8 per cent by *Lenzites trabea* (inadvertently listed as *L. sepiaria* in the published article). The sapwood proved far less resistant, with losses varying from less than 1 per cent to 37 per cent in the case of *Lenzites trabea*.

In 1917 Pfeiffer³ reported on eight species of woods from the Dutch East Indies. The tests were made by a fermentation method using methane-producing bacteria secured from ditch soil. Ten grams of the powdered wood were placed in 125 cubic centimeter bottles, together with 5 grams calcium chloride and a sufficient solution of di-potassium phosphate, ammonium chloride, and magnesium sulphate to make 0.1 per cent concentration of each of these substances. The contents of the bottle were then thoroughly mixed and inoculated either with a powdered dry culture of the bacteria on cellulose or with an inoculated solution taken from another test bottle. After the bottles had been filled with tap water and fitted with rubber stoppers through which were inserted closed glass tubes for measuring the gas formed, they were incubated at 36° C. for twenty-five days.

The author states that the results secured by this method agree quite well with what is already known regarding the general durability of the species tested, and that those woods which produce a considerable amount of gas will not stand the tropical climate for more than five years.

Data on the eight species reported are arranged as follows, according to their resistance to fermentation:

Total gas produced in twenty-three days (average of three series.)

Heartwood.	cc.
<i>Eusideroxylon zwageri</i>	0.3
<i>Tectona grandis</i>	1.2
<i>Shorea</i> sp. (Ressak)	1.35
<i>Dipterocarpus trinervis</i>	16.5
<i>Shorea</i> sp. (Meranti)	33.8
Sapwood.	
<i>Tectona grandis</i>	40.3
<i>Dipterocarpus trinervis</i>	46.8
Not stated whether heartwood or sapwood. ^a	
<i>Alstonia scholaris</i>	6.02

^a As regards color, gross structure and weight, there is practically no distinction between heart and sapwood in this species.

³ De waarde van wetenschappelijk onderzoek voor de vaststelling van technische eigenschappen van hout. (The value of scientific research for the determination of the technical properties of timber.) Doctorate Thesis, Amsterdam (1917) 163-188.

In 1921 Schmitz ⁴ tested the durability of *Ginkgo biloba* by exposing heartwood blocks approximately 1 by 1 by 2 inches in quart Mason jars, six blocks to a jar. These were inoculated with five species of fungi after sterilization at 15 pounds steam pressure for twenty minutes. The results after four months were:

	Loss in weight (per cent).
<i>Polystictus versicolor</i>	3.0
<i>Polyporus lucidus</i>	3.3
<i>Trametes pini</i>	3.6
<i>Fomes roseus</i>	3.6
<i>Fomes pinicola</i>	4.5
<i>Lenzites sepiaria</i>	7.8

The author concludes from these tests that the wood of *Ginkgo biloba* is not unusually resistant to decay under the conditions imposed.

In 1924 Kitajima ⁵ published a short report in Japanese on the relative durability of a number of American and Japanese timbers, of which only the latter will be mentioned here.

His test was made by placing clear selected heartwood blocks $1\frac{3}{16}$ by $1\frac{3}{16}$ by $4\frac{3}{4}$ inches side by side on a board severely rotted by *Merulius lachrymans* in a moist cellar. The hardwood blocks were oven-dried and weighed before test, but the dry weights of the conifers were computed from the specific gravity and volume, the method of derivation being somewhat obscure in the paper at hand. The results after nineteen months were as follows:

	Loss in weight (per cent).
<i>Thujaopsis dolabrata</i>	2
<i>Larix leptolepis</i>	2
<i>Cryptomeria japonica</i>	15
<i>Chamaecyparis obtusa</i>	20
<i>Abies sachalinensis</i>	26
<i>Pinus densiflora</i>	33
<i>Picea ajanensis</i>	37
<i>Tsuga sieboldii</i>	40
<i>Abies firma</i>	40

The original work reported in the present paper was carried out by Reinking during the period 1916 to 1921, at which time

⁴ Journ. of Forestry 19 (1921) 165-166.

⁵ The writers have seen only a translation of this by Kitajima and cannot cite the original publication. The translated title is, "On the Durability of American Coniferous Woods."

he was plant pathologist at the College of Agriculture, University of the Philippines, Los Baños, Philippine Islands. Flask tests were made on fifteen kinds of Philippine woods and Southern yellow pine from the United States in the following manner, using five named species of fungi, identified mainly by C. G. Lloyd, and nine unnamed cultures of wood-destroying hymenomycetes isolated from various species of local timber.

Wide-mouthed Erlenmeyer flasks of 2 liters capacity were prepared with a quantity of culture blocks, 2 by 2 by 5 centimeters, of nondurable species such as *Erythrina indica*, *Aleurites moluccana*, and *Pentacme contorta*, among which were mixed the 2 by 2 by 5 centimeter test blocks.

The culture blocks were first boiled in tap water, then immersed in cold tap water until saturated, and finally sterilized for two hours at 10 to 12 pounds pressure in the autoclave. The test blocks were oven-dried for forty-eight hours at 100° C. and then cooled and weighed. The culture flasks were prepared by first placing a layer of water-saturated cotton in the bottom. A triple layer of moist culture blocks as they came from the sterilizer was then placed over the cotton. Alternating layers of test blocks and culture blocks were then put in the flask until it was nearly full. A layer of water-saturated cotton was finally placed over the top of the pile of blocks to hold the moisture. Tap water to about ½-inch depth on the bottom of the flask was added. The flasks were then plugged fairly tightly with absorbent cotton and sterilized on three successive days in the autoclave at 10 to 12 pounds pressure for 60, 45, and 30 minutes, respectively. After sterilization the cotton plugs were trimmed and the tops covered with cloth caps saturated with a 1-to-1000 mercuric chloride solution.

Pure cultures of the fungi to be tested were first grown on bean cultures in test tubes. When the fungus was well established, the bean cultures were poured into the flask, the operation being carried out in a culture case sterilized with mercuric chloride. The flasks were then labelled with the name of the organism, the species of test and culture blocks, and the date of inoculation. They were held in a dust-free case at room temperature for periods varying from seven to twenty-eight months.

At the end of each experiment the character of the fungus growth, the effect on the test blocks and the culture blocks, and the weight of the oven-dried test blocks were recorded. The

loss in weight and the character of the rot produced in the various woods by the specified organisms were in this way determined. The data on these cultures are given in Table 1.

Schneider ⁶ gives the following durability ratings for the woods ⁷ herein reported:

Very durable.	Durable.
Molave.	Katmon.
Yakal.	Narra.
Fairly durable.	Tabigi.
Apitong.	Tindalo.
Guijo.	Not durable.
Tangile.	Lauans.
	Malaanonang.
	Lumbang.

Aroma and dapdap are not rated, although the heartwood is reputed to be durable and the sapwood perishable.

It is seen that the general order of durability derived from the laboratory tests agrees fairly well with the service data published by Schneider. The harder, heavier woods are usually the more durable, but the depth of color of the heartwood bears very little relation to resistance of the wood to fungus attack. Averaging the figures for the different tests which extended over a period of fifteen months or more we arrive at the following losses for the different species or groups:

	Loss in weight (per cent).
Molave	Slight
Yakal	17.5
Tindalo	18.0
Tabigi	21.3
Apitong	27.8
Narra	28.0
Red lauan	42.9
Malaanonang	49.0
White lauan	52.5
Guijo	55.8
Lauan	57.3
Aroma (mostly sapwood)	60.3

It will be noted from the list of scientific names at the end of the paper that the specific identity of the woods tested was not determined in a number of cases, since the same common

⁶ Bull. Philip. Bu. Forestry 14 (1916).

⁷ Spelling of names is corrected in accordance with Philippine Bureau of Forestry Bulletin 23.

TABLE 1.—Durability of Philippine woods.

No.	Organism used. ^a	Dura- tion of test.	Wood.	Oven-dry weight.			Loss in weight.	Remarks.
				Before test.	After test.	Grams.		
		Months.		Grams.	Grams.	Per cent.		
6966	Undetermined	17	Apitong	25.2	18.2	27.8		Rotted in patches; decay whitish.
6041	do	17	Aroma	12.6	5.0	60.3		Severely decayed and bleached.
2950	<i>Daedalea flarida</i> Lév.	25½	Katmon					Severely decayed.
6966	Undetermined	17	Dapdap (culture blocks)					Severely decayed, soft; 3 tests.
7389	<i>Polyorus sanguineus</i> L.	15½	do					Severely decayed, rather friable.
5921	Undetermined	16	do					Severely decayed.
5922	do	16	do					Severely decayed, especially at surface.
5924	do	16½	do					Moderately decayed; too wet.
6718	do	16½	do					Severely decayed.
6041	do	17	do					Severely decayed, rather friable.
5928	<i>Polyorus sanguineus</i> L.	16½	do					Do.
5927	<i>Trametes versatilis</i> Berk.	16½	do					Very severely decayed, friable.
5955	<i>Trametes meyenii</i> Kl.	28	do					Completely decayed.
11170	<i>Polyorus sanguineus</i> L.	9½	Guijo	49.4	38.9	21.2		Slightly bleached decay in patches; poor growth; 3 blocks.
11605	Undetermined	7	do	43.4	30.0	30.9		Whitish decay in patches.
5927	<i>Trametes versatilis</i> Berk.	16½	do	26.0	11.5	55.8		Moderately decayed throughout.
11170	<i>Polyorus sanguineus</i> L.	9½	Lauan	21.8	19.7	9.6		Slightly decayed; too wet; 3 blocks.
7389	do	15½	do	18.0	5.5	69.4		Severely decayed throughout.
11605	Undetermined	7	do	19.2	17.3	9.9		Moderately decayed; too wet.
5955	<i>Trametes meyenii</i> Kl.	28	do	17.4	9.6	44.8		Severely decayed, soft.
5966	Undetermined	16½	do					Severely decayed throughout, soft.
5921	do	16	Red lauan	19.2	14.0	27.1		Severely decayed in patches.
5922	do	16	do	20.0	6.1	69.5		Do.
6718	do	16½	do	26.7	18.9	29.2		Severely decayed; rot whitish; 3 blocks.

5928	<i>Polyporus sanguineus</i> L.	16½	do.	15.3	7.4	51.6	Severely decayed; soft.
6966	Undetermined	17½	White lauan				Severely decayed.
5926	do.	16½	do.	19.4	6.7	65.5	Severely decayed throughout; 3 blocks.
5922	do.	15½	do.	14.4	8.4	41.7	Severely decayed at surface.
6041	do.	17	do.	14.4	7.8	45.8	Severely decayed.
5924	do.	16½	White lauan (culture blocks)				Severely decayed throughout.
5926	do.	16½	Lumbang (culture blocks)				Severely decayed throughout, friable.
11605	do.	7	do.	15.0	9.7	35.3	Severely decayed, soft.
5966	do.	16½	do.				Severely decayed throughout.
6966	do.	17	Malanonang	14.5	7.4	49.0	Severely decayed.
3003	<i>Xerotus nigrita</i> Lévy	25½	Molave				Slight decay only in pieces on moist cotton.
11170	<i>Polyporus sanguineus</i> L.	9½	Narra	37.5	35.9	4.3	Slightly decayed in patches; 3 blocks.
5922	Undetermined	16	do.	18.9	12.4	34.4	Moderately decayed, especially at surface.
6718	do.	15½	do.	18.3	11.1	39.3	Moderately to severely decayed.
11605	do.	7	do.	31.5	28.7	8.9	Slightly decayed.
5926	do.	16½	Narra (heart)	10.0	7.4	26.0	Severely decayed; 2 blocks.
5927	<i>Trametes versatilis</i> Berk.	16½	Narra (light colored)	12.0	11.9	0.8	Slightly decayed in patches.
5927	do.	16½	Red narra	28.5	26.3	7.7	Slight surface rot; wood darkened.
5955	<i>Trametes meyenii</i> Kl.	28	do.	23.1	15.7	32.0	Moderately to severely decayed; rot whitish.
5966	Undetermined	16½	do.				Slightly decayed.
6966	do.	17	White narra	18.7	8.4	55.1	Severely decayed and bleached.
5966	do.	16½	do.				Severely decayed throughout.
5921	do.	16	Pine				Slightly decayed.
5922	do.	16	Pine (boxes from U. S.)	11.6	6.8	41.4	Surface severely decayed.
5924	do.	16	Tabigi	20.2	15.9	21.3	Moderately decayed in patches.
2950	<i>Daedalea flarida</i> Lévy	25½	Tangile				Moderately decayed.
5922	Undetermined	16	Tindalo	31.7	26.0	18.0	Moderately decayed and bleached especially at surface.
6966	do.	17	Yakal	35.7	19.3	45.9	Moderately decayed.
6966	do.	17	do.	35.1	26.0	25.9	Severely decayed and bleached, especially at surface.
5926	do.	16½	do.	35.0	31.3	10.6	Moderately decayed; 3 blocks.

TABLE 1. *Durability of Philippine woods*—Continued.

No.	Organism used. ^a	Duration of test.	Wood.	Oven-dry weight.		Loss in weight.	Remarks.
				Before test.	After test.		
5922	Undetermined	Months.					
5924	do	16½	do	31.1	27.2	12.5	Moderately decayed.
5928	<i>Polyporus sanguineus</i> L.	16½	do	20.1	19.6	2.5	Slightly decayed at surface.
7389	do	15½	do	39.9	38.8	2.8	Do.
5966	Undetermined	16½	do	41.4	34.4	16.9	Do.
							Slightly decayed in cracks and at end.

^a The organisms were isolated from the following hosts: Nos. 2950 and 3003, from bridge flooring, *Shorea guiso*; No. 5921, from dead branch; Nos. 5922 and 5924, from timber, *Pentacme contorta*; No. 5926, from timber, *Shorea guiso*; No. 5927, from railroad tie, *Shorea guiso*; No. 5928, from board *Dipterocarpus grandiflorus*; No. 5955, from stump, *Cordia myza*; No. 5966, from railroad tie, *Shorea guiso*; No. 6041, from dead branch; No. 6718, from dead wood, *Parashorea plicata*; No. 6966, from rotten log; No. 7389, from timber, *Quercus* sp.; No. 11170, from building material; No. 11605, from dead wood. NOTE: The scientific names for the woods tested are given, as far as possible, at the end of the article.

name may be commercially applied to different species within the same genus or even to particular species in different genera. The physical characteristics determine the local grouping, but this does not imply that there may not be differences in chemical constitution which would affect the durability.

For the benefit of those not familiar with tropical woods, brief descriptions may aid in interpreting the above data. These descriptions are largely condensed from statements in Bureau of Forestry Bulletin 15.

MOLAVE is a hard, heavy wood with a specific gravity up to 0.880; heartwood pale straw color to light brown, sometimes with greenish tints; lime water or other alkalis stain it bright greenish yellow; chips give yellow color to water; sapwood small, scarcely lighter than heartwood.

YAKAL is a trade name for several species of *Hopea*, *Shorea*, and *Isoptera*. Yakal proper is *Hopea plagata*. *Hopea* woods are hard to very hard, tough, heavy, with a specific gravity up to 0.834; heartwood pale yellow to light yellowish brown, darkening rapidly on exposure, sometimes with narrow, irregular greenish streaks which in drying turn greenish black; sapwood 2 to 8 centimeters thick, pale yellow when fresh, often staining to a dirty gray, rather sharply distinguished from heartwood.

Yakals of the *Shorea* and *Isoptera* groups are somewhat coarser textured than those of the *Hopea* group, otherwise they have about the same characteristics.

TINDALO is a hard, heavy wood, with specific gravity up to 0.878; heartwood saffron or pale orange, turning with age to a deep rich red, sometimes with irregular blackish streaks; odor of raw beans or peanuts; sapwood 2 to 4 centimeters thick, white, perishable.

TABIGI is a tree of the mangrove swamps, with a moderately hard and moderately heavy wood; heartwood light red to deep wine color; sapwood small, whitish, rather perishable.

APITONG yields a moderately hard to hard, moderately heavy to heavy wood, with a specific gravity up to 0.645; heartwood light ashy red to reddish brown or dark brown; resinous odor; sapwood 2 to 8 centimeters, light grayish or brownish when fresh, not sharply delimited from heartwood.

NARRA is a moderately hard to hard, moderately heavy wood, with specific gravity up to 0.580; heartwood ranges from pale straw color through all possible shades of pink, salmon, and red to deep blood red and occasionally dull brown without any red

tint; as far as known, all species of *Pterocarpus* may produce wood of any color, the commercial classification of "red," "yellow," and "white" narra being applicable only after the tree is felled and sawn; sapwood 2 to 8 centimeters, whitish, perishable.

LAUANS. Species in at least five genera are included under this name.

RED LAUAN is a soft to moderately hard, light to moderately heavy wood, with specific gravity up to 0.542; coarse textured and cross-grained; heartwood light red to dark reddish brown; sapwood 3 to 5 centimeters, reddish or brownish white, not sharply delimited from heartwood.

WHITE LAUAN wood is soft to moderately hard, light to moderately heavy; heartwood pale grayish brown to light reddish brown; sapwood whitish, turning pale silvery gray in drying, but often staining to dirty grayish brown, not sharply delimited from heartwood.

MALAANONANG produces a wood of the lauan type, light and soft heartwood pale brown; sapwood small, somewhat paler than heartwood.

GUIJO has a moderately heavy to heavy, moderately hard to hard wood, with specific gravity up to 0.708; heartwood light ashy brown to brown, sometimes with distinct reddish tint; faint odor of resin; sapwood 2 to 5 centimeters, light grayish brown, not sharply delimited from heartwood.

KATMON wood is hard and heavy, with a specific gravity up to 0.816; heartwood light brick red to dark reddish brown; sapwood pale red, not sharply delimited from heartwood.

LUMBANG produces a light, soft, whitish wood, with no distinction between sapwood and heartwood.

TANGILE wood is the hardest, finest-textured and, with the exception of red lauan, the darkest red of the lauan class; soft to moderately hard and light to moderately heavy, with a specific gravity up to 0.509; heartwood pale red to dark reddish brown; sapwood 2 to 5 centimeters, pale grayish brown, not sharply delimited from heartwood.

DAPDAP is a very light corky wood often used for floats and buoys; sapwood and heartwood not distinguishable by gross characteristics.

AROMA has a yellowish brown, moderately hard and heavy heartwood, more durable than the rather large, whitish sapwood.

Little is known regarding the substances in wood which render it resistant to fungus attack. In general, it is assumed, with considerable experimental evidence, that this resistance resides largely in toxic substances within the wood. In the case of highly resinous woods, however, the action of the toxic constituents in the resin is undoubtedly supplemented by a waterproofing action of the resinous materials.

Wehmer⁸ has shown that the extractives from European oak, consisting largely of tannin bodies, are in part responsible for the durability of that species. Investigations reported⁹ from the Forest Products Laboratory also indicate that the hot-water extractives from the heartwood of such highly durable species as catalpa (*Catalpa speciosa*), red mulberry (*Morus rubra*), black locust (*Robinia pseudo-acacia*), white oak (*Quercus alba*), etc., may totally, or almost completely, inhibit the growth of *Fomes annosus* in a 50 per cent¹⁰ concentration; or even in 10 per cent concentration in the case of black locust and red mulberry. While these are very high concentrations when compared with an effective antiseptic, nevertheless the experiments show that the extractives are poisonous to a considerable degree in some cases.

The constitution of these extractives is little understood. Chestnut (*Castanea*), oak, black locust, and mulberry are known to contain tannin. Osage orange (*Toxylon pomiferum*), black walnut (*Juglans nigra*), and redwood (*Sequoia sempervirens*) contain large quantities of soluble coloring matter of unknown composition. From greenheart (*Nectandra rodiaei*) at least four alkaloids have been isolated from the wood and bark. Certain conifers, such as the cedars, cypress, etc., contain volatile oils which are known to be toxic. Bateman¹¹ thinks that the terpenes and terpineols (pine oils), contained in the resins of pines and certain other conifers, are important in durability when in sufficient quantity to be effective. Kitajima¹² has tested the extracted oil of *Thujaopsis dolabrata*, one of the very

⁸ Mycol. Centralbl. 1 (May, 1912) 138-148; 1 (June, 1912) 166-174.

⁹ Hawley, L. F., L. C. Fleck, and C. A. Richards, Journ. Ind. and Eng. Chem. 15 (July, 1924) 699.

¹⁰ The total extractive from 100 grams of wood is concentrated to 100 cubic centimeters, and then diluted to one-half.

¹¹ Southern Lumberman 115 (July 5, 1924) 51.

¹² Forest Experiment Station [Meguro, Tokyo, Japan] Bull. 17 (September, 1917).

durable woods of Japan, and found that 0.05 per cent concentration in agar prevented the growth of *Poria vaporaria*, while from 0.25 to above 0.50 per cent of turpentine oil and the oils from *Chamaecyparis obtusa* and *Chamaecyparis pisifera*, were required.

It appears, then, that the effective toxic constituents in wood vary widely, the tannin groups being important in many species, essential oils (sometimes rather high-boiling) in many conifers, and alkaloids in certain other species. As the chemistry of wood becomes better known many constituents will undoubtedly come to light.

SUMMARY

The paper presents data on the resistance to decay of fifteen kinds of common Philippine woods and a species of southern yellow pine from the United States. These were tested against five named species and nine unnamed ones of common and destructive Philippine fungi. Small blocks of wood were inserted in 2-liter Erlenmeyer flasks, inoculated, and allowed to decay for periods varying up to twenty-eight months, but for the most part sixteen to seventeen months. The severity of decay is indicated by loss in weight as well as by the physical condition when removed from the flasks. The relative scale of durability derived accords well with the published records of the resistance of the same woods to fungus attack under natural or service conditions, molave (*Vitex*), yakal (*Hopea* etc.), and tindalo (*Pahudia*) leading the list for durability, while the softer woods, such as the lauans (*Shorea*, *Parashorea*, *Pentacme*), guijo (*Shorea*), katmon (*Dillenia*), dapdap (*Erythrina*), and mala-anonang (*Shorea*) are quite perishable under conditions favorable to decay. Narra (*Pterocarpus*) and apitong (*Dipterocarpus*) proved moderately durable.

SCIENTIFIC NAMES OF PHILIPPINE WOODS TESTED BY REINKING FOR DURABILITY

- Apitong. *Dipterocarpus grandiflorus* Blco. and *D. vernicifluus* Blco.
Aroma. *Acacia farnesiana* (L.) Willd.
Katmon. *Dillenia philippinensis* Rolfe and *D. luzonensis* (Vid.) Mart.
Dapdap. *Erythrina variegata* Linn.
Guijo. *Shorea guiso* (Blco.) Blm.
Red lauan. *Shorea negrosensis* Foxw. and other *Shorea* species with wood of the same type.

White lauau. *Pentacme contorta* (Vid.) Merr. and Rolfe, *Parashorea malaanonan* (Blco.) Merr. and *Shorea eximia* (Miq.) Scheff.

Lumbang. *Aleurites moluccana* Willd.

Malaanonang. *Shorea polita* Vid.

Molave. *Vitex parviflora* Juss.

Narra.

Red narra. *Pterocarpus indicus* Willd.

White narra. *Pterocarpus vidalianus* Rolfe.

Pine. Southern yellow pine group from the United States.

Tabigi. *Xylocarpus granatum* Koen.

Tangile. *Shorea polysperma* (Blco.) Merr.

Tindalo. *Pahudia rhomboidea* (Blco.) Prain.

Yakal. *Hopea plagata* (Blco.) Vid., *Isoptera borneensis* Scheff., and *Shorea balangeran* (Korth.) Dyer.

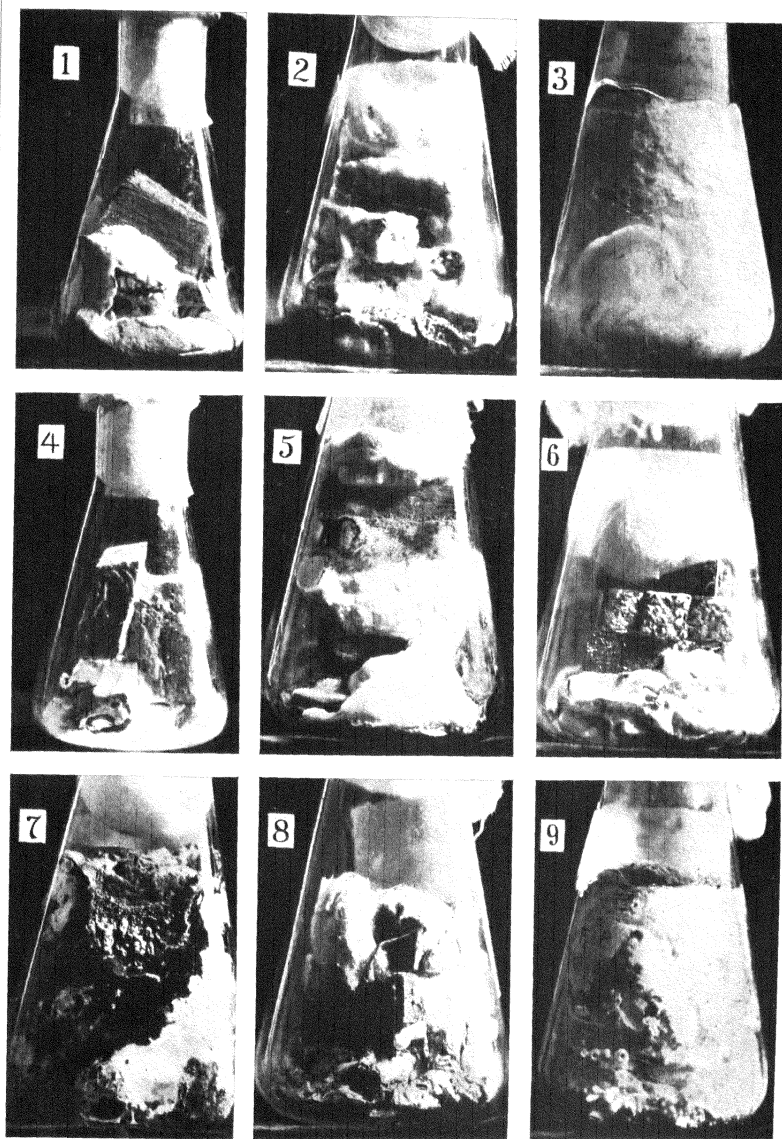
ILLUSTRATIONS

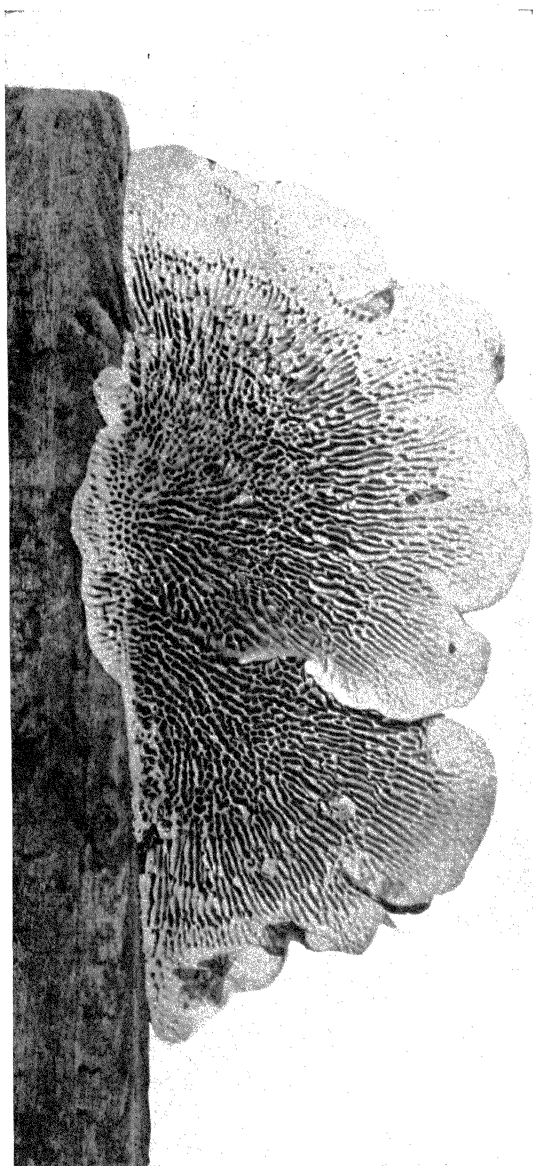
PLATE 1. CULTURES IN LARGE ERLLENMEYER FLASKS

- FIG. 1. *Xerotus nigrita* Lév., No. 3003, 25 $\frac{1}{4}$ months.
2. *Trametes meyenii* Kl., No. 5955, 27 $\frac{3}{4}$ months.
3. *Polyporus sanguineus* L., No. 5928, 16 months.
4. *Trametes versatilis* Berk., No. 5927, 16 $\frac{1}{2}$ months.
5. *Daedalea flavida* Lév., No. 2950, 25 $\frac{1}{4}$ months.
6. Undetermined fungus, 16 $\frac{1}{2}$ months.
7. Undetermined, No. 5924, 15 $\frac{3}{4}$ months.
8. Undetermined, No. 6966, 16 $\frac{1}{2}$ months.
9. Undetermined, No. 5922, 15 $\frac{1}{2}$ months.

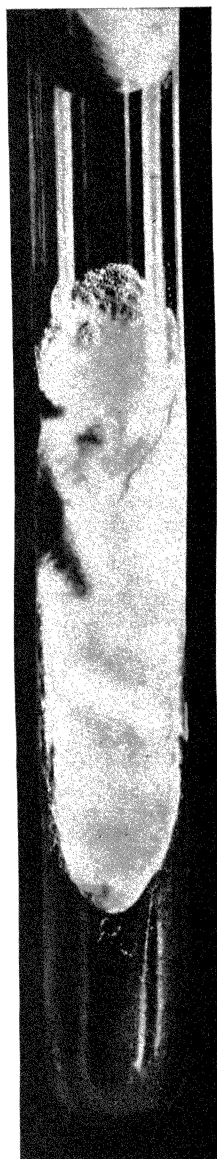
PLATE 2

- FIG. 1. *Daedalea flavida* Lév. No. 2950, lower surface of sporophore.
Natural size.
2. Undetermined polypore. Natural size.





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PLATE 2. DAEDALEA FLAVIDA LÉV.

THE RESISTANCE AND THE BLOOD SUGAR OF ANIMALS INFECTED WITH *TRYPANOSOMA EVANSI*

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and

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SEVEN TEXT FIGURES

The pathological processes that ultimately cause the death of animals infected with pathogenic trypanosomes have been explained in different ways. Some believe that they are due to the liberation of a toxic substance by the disintegrating organisms. Reichenow (1921) finds support for this view by the observation that in sleeping sickness the temperature reaches its maximum height after the disappearance of the parasites from the peripheral circulation. The experience of Edwards (1926) as well as our own on the fatal results that often follow the injection of tartar emetic in horses affected with surra when the trypanosomes are very abundant in the circulation, is also a point in favor of the toxin theory.

Kligler, Geiger, and Comaroff (1929), on the other hand, are of the opinion that "the pathological processes are engendered by the metabolism of the trypanosomes which results in the rapid production of lactic acid, leading to exhaustion of the alkali reserve and probably also to a depression of the oxidative processes by the specific effect of lactic acid on the hæmoglobin."

Another explanation is that given by Schern (1925, 28) and Fenyvessy (1926), who ascribe the pathogenicity of trypanosomes to a disturbance of the sugar metabolism of infected animals. They have reported the results of experiments in which it was shown that the amount of dextrose in the blood was decreased in proportion to the number of organisms present

in the blood (Schern) or to the progress of the infection (Fenyvessy). They believe that the low blood-sugar content, or hypoglycaemia, is the immediate cause of death and is brought about by the metabolism of the blood sugar by the parasites, since in experiments in vitro they observed the utilization of this carbohydrate by the parasites. Later Yorke, Adams, and Murgatroyd (1929) also showed that trypanosomes suspended in serum consume large quantities of dextrose. Bruynoghe, Dubois, and Bourkaert (1927) confirmed Schern's work in so far as the hypoglycaemia is concerned, but they maintained that the trypanosomes do not consume the sugar of the blood directly but only serve to reduce its titre by the production of an insulinlike substance.

The observations of Schern and of Fenyvessy have generally been accepted and only Zotta and Radacovici (1929 *a, b*) have differed from them. The latter studied the blood sugar of guinea pigs infected with *Trypanosoma brucei* and their conclusions, as summarized by Yorke (1930), are the following:

1. In guinea pigs infected with nagana a progressive hypoglycaemia, proportional to the increasing number of trypanosomes in the blood, was not observed.

2. The variations of the degree of glycaemia were irregular, sometimes above and sometimes below the normal, suggestive of a disorder of the sugar-regulating centre, but in no case of a direct utilization of the blood glucose by the trypanosomes.

3. On the contrary, the constant phenomenon in the evolution of trypanosomiasis is a pre-mortal hypoglycaemia.

4. This appears quite suddenly without any previous progressive diminution in the blood sugar; in fact, it is more often preceded by a phase of hyperglycaemia.

5. The terminal hypoglycaemia is perhaps due to a nervous mechanism set in motion by the direct action of the trypanotoxin on the sugar-regulation centre or by an indirect action through the suprarenal capsules.

6. Moreover, terminal hypoglycaemia is not specific for trypanosomiasis. It is a biological state characterizing the pre-mortal period of a large number of diseases.

These views on the causation of injury and death in trypanosomiasis, supported as they are by either clinical or experimental evidence, are significant from the viewpoint of chemotherapy. Hence, while engaged in studies on the treatment of surra, we availed ourselves of the opportunity to study the blood sugar of animals infected with the disease. At the same time counts were made on the number of trypanosomes in the peripheral circulation and the rate of multiplication and increase

of the parasites were estimated in order to find out if, as claimed by Schern and by Fenyvessy, the quantity of the blood sugar varies in inverse proportion to the number of trypanosomes or to the progress of the infection; and, if this should prove to be the case, to determine if the resistance of certain animals has anything to do with their ability to maintain a normal blood-sugar content.

MATERIALS AND METHODS

Animals used.—Previous studies on the blood sugar in experimental trypanosomiasis have mostly been carried out on particular groups of animals only. In as much as different species of hosts may respond differently to the presence of the same species of trypanosome, the following were utilized in the present studies; namely, white rats, guinea pigs, cats, dogs, and horses. These were inoculated subcutaneously with a strain of *Trypanosoma evansi* isolated from a surra horse and maintained in the laboratory by direct passage through guinea pigs. Before an animal was infected or during the incubation period of the disease, one or more sugar determinations were made to serve as controls. After the appearance of the parasites in the peripheral circulation, the sugar readings were made daily or every two days, the number of trypanosomes in the blood counted, and the rate of multiplication of the parasites estimated.

Determination of the blood sugar.—The sugar determinations were made according to the new method of Folin (1928). The blood samples were obtained from the veins of the ear in horses, dogs, and cats; from the veins of the abdomen or legs of guinea pigs; and from the tail or legs of rats. The determinations were made in most of the cases between 11 and 12 o'clock in the morning.

Estimation of the resistance of host animals.—The method of Taliaferro and Taliaferro (1922) for measuring the resistance of animals against trypanosome infections was adopted. For the details of the method the original paper should be consulted. Briefly, however, it consists in counting the parasites in the blood at repeated intervals from the day they become visible in the peripheral circulation and at the same time estimating their coefficient of variation as a measure of their reproductive activity. The rationale of this method is based on the fact that the variability of size in a population of organisms in which

there is active reproduction with the consequent production of young and intermediate stages, is greater than in a population in which there is little or no reproduction and in which the members are all, therefore, more or less full-grown adults. As Taliaferro (1929) puts it,

Granted that a parasite not only has successfully invaded its specific host but has started reproduction, it is evident that if no resistance is operative the number of parasites must increase in the blood at a uniform rate. Also, due to the fission method of protozoan reproduction such an unmolested increase would cause the number to accumulate according to a geometrical progression series ($a, ar, ar^2, ar^3, ar^4 \dots ar^n$, for example, 1, 2, 4, 8, 16 etc.) If it does not progress uniformly in this manner, (and the majority of infections do not), for example, if after the parasite has appeared in the host as an infection, its numbers either remain constant or decrease, it may be concluded that some type of resistance is operative.

DISCUSSION OF RESULTS

The results obtained in the different groups of animals were so uniform that it will suffice to cite one or two representative cases in each group from which to draw conclusions.

Rats.—Ten white rats were infected. Incubation period, four to five days; duration of infection (that is, from the time the trypanosomes were first visible in the peripheral circulation until the host animal died), four to six days. For the other data, figs. 1 and 2 may be consulted.

It will be seen from the figures that in rats *surra* runs a continuous progressive course, the trypanosomes never leaving the peripheral circulation after they have effected their entrance. On the other hand they undergo rapid multiplication, as evidenced by their coefficient of variation which is always high, as a result of which they increase in number. In the beginning of the infection the increase is usually slow and gradual, but towards the end it becomes so rapid that at the time of, or shortly before, the death of the host there may be from 650,000 to 1,000,000 trypanosomes per cubic millimeter of blood. This behavior of the organism is in conformity with the contention of Kligler and Comaroff (1929) that rats possess a certain degree of resistance against *T. evansi*. This resistance, the nature of which is still a matter of conjecture, manifests itself during the first two or three days after the appearance of the organisms in the peripheral circulation when their number is kept at a low level (2,000 to 140,000 trypanosomes per cubic millimeter of blood). After that time, it breaks down, and the

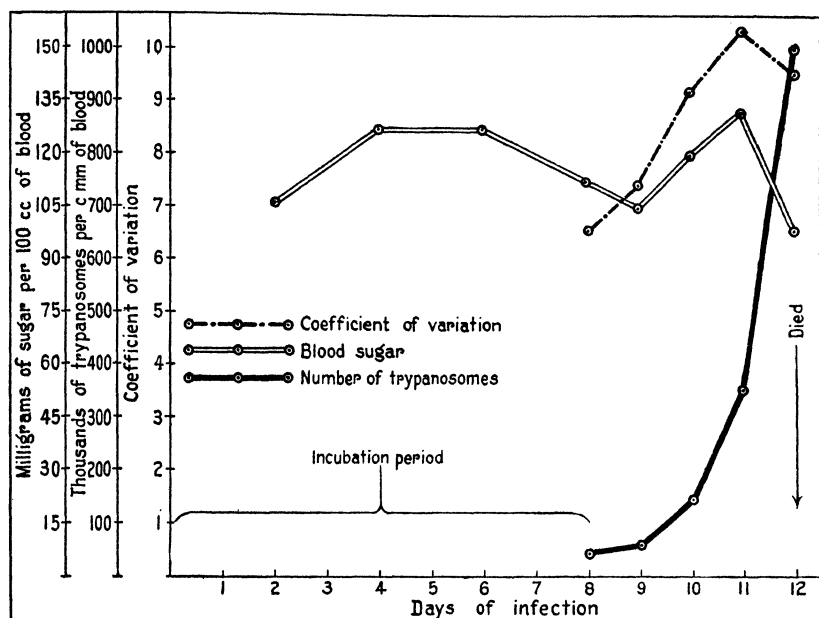


FIG. 1. Blood sugar and the course of infection in rat 2.

number of the parasites in the blood quickly reaches the maximum and the host animal dies.

With reference to the blood sugar, our findings are in accord with those of Zotta and Radacovici in that none of our rats developed the condition of progressive hypoglycæmia. The data of rat 2, as shown in fig. 1, are characteristic for the majority of animals, the dextrose content of the blood remaining normal throughout (at least 100 milligrams per 100 cubic centimeters of blood). Only in one rat, No. 7, as shown in fig. 2, was there a diminution in the amount of blood sugar and this occurred on the day the animal died. In fact, the animal died in less than two hours after its blood had been obtained for sugar determination; the sugar reading was 45 milligrams per 100 cubic centimeters of blood. The condition is, therefore, what Zotta and Radacovici call a premortal hypoglycæmia, which occurs, according to these authors, not only in trypanosomiasis but also in several other diseases.

Guinea pigs.—Three guinea pigs were infected. Incubation period, six to ten days; duration of infection, fifty-four to ninety-five days. For the other data, fig. 3, based on the records of guinea pig 1, may be consulted.

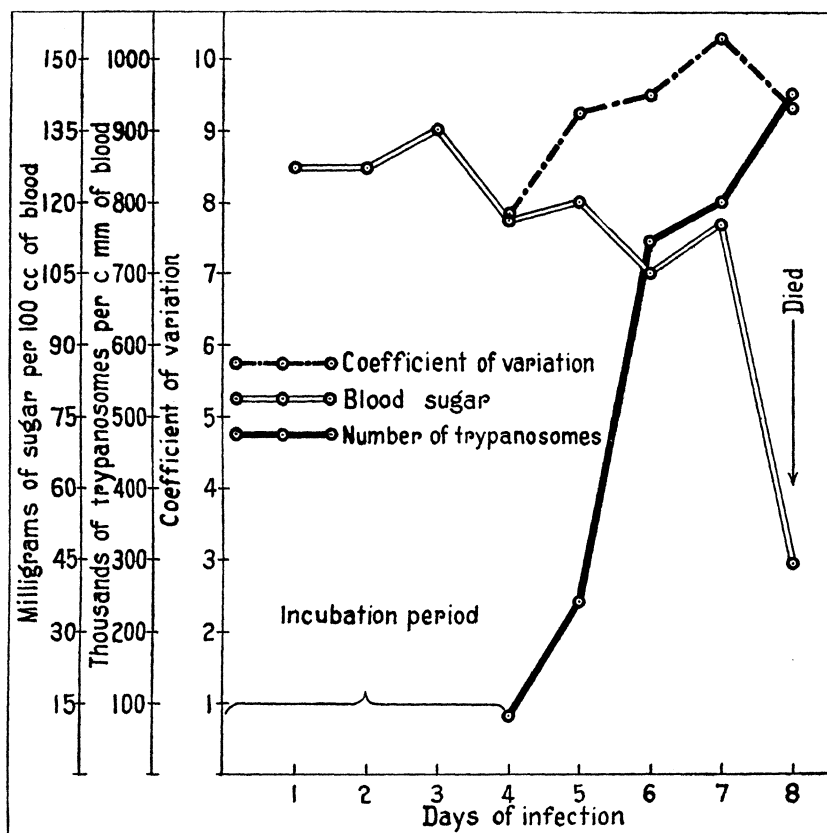


FIG. 2. Blood sugar and the course of infection in rat 7.

The figure shows the generally well-known fact that in guinea pigs infection with surra is of long duration and of the relapsing type; that is, there are times following the initial incubation period when the parasite, after it has started to multiply, may either be greatly reduced in numbers or disappear altogether from the peripheral circulation only to be seen again and to increase in number after so many days. These crises and relapses, as they are called, may be repeated a number of times. As in the case of the rat, however, the coefficient of variation remains constantly high, an indication that there is no abatement of the rate of multiplication. This being the case, the fluctuations in the numbers of the parasite may be explained by assuming that the guinea pig possesses a mechanism of resistance which when functioning in good order, brings about the de-

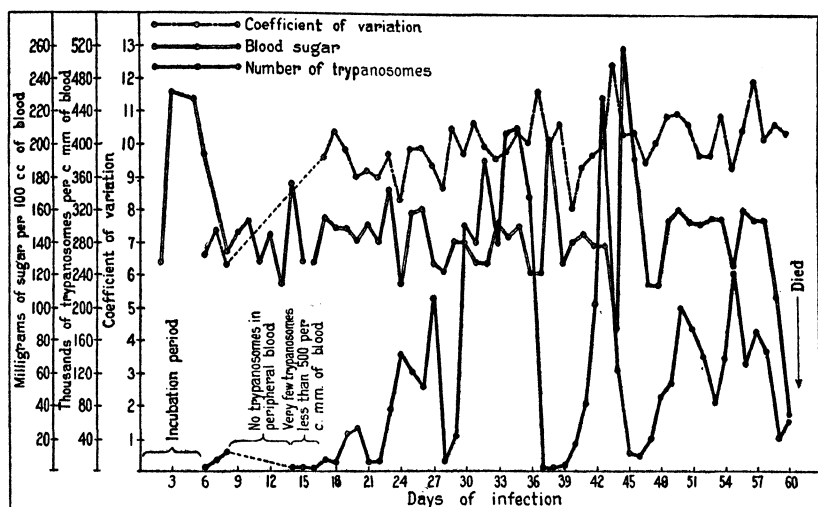


FIG. 8. Blood sugar and the course of infection in guinea pig 1.

struction of trypanosomes to the extent that they become so scarce at times that it is difficult or even impossible to detect them in the peripheral blood. In this respect and also in the fact that the same phenomenon may occur a number of times before the host animal succumbs, is the resistance of the guinea pig superior to that of the rat. What finally brings about the fatal end in these animals is not very clear, for at the time of, or sometime before death the number of trypanosomes in the circulation is usually not large.

The observations on the blood sugar were similar to those in rats in that only a terminal hypoglycæmia was registered in all the three animals studied. The dextrose reading during the infection was mostly between 100 and 200 milligrams per 100 cubic centimeters of blood. On two occasions, in the case of guinea pig 1, it even went up much beyond the 200 limit, thus presenting the reverse picture, namely, hyperglycæmia.

Cats.—Three cats were infected. Incubation period, six to eleven days; duration of infection, four to thirty-two days. For the other data, figs. 4 and 5 may be consulted.

It is apparent from the figures that in cats *surra* may be either an acute disease similar to that seen in rats (cat 1, fig. 4; also cat 2) or a chronic relapsing infection that possesses some of the characteristics of that observed in guinea pigs (cat 3, fig. 5). In the latter case, although the trypanosomes

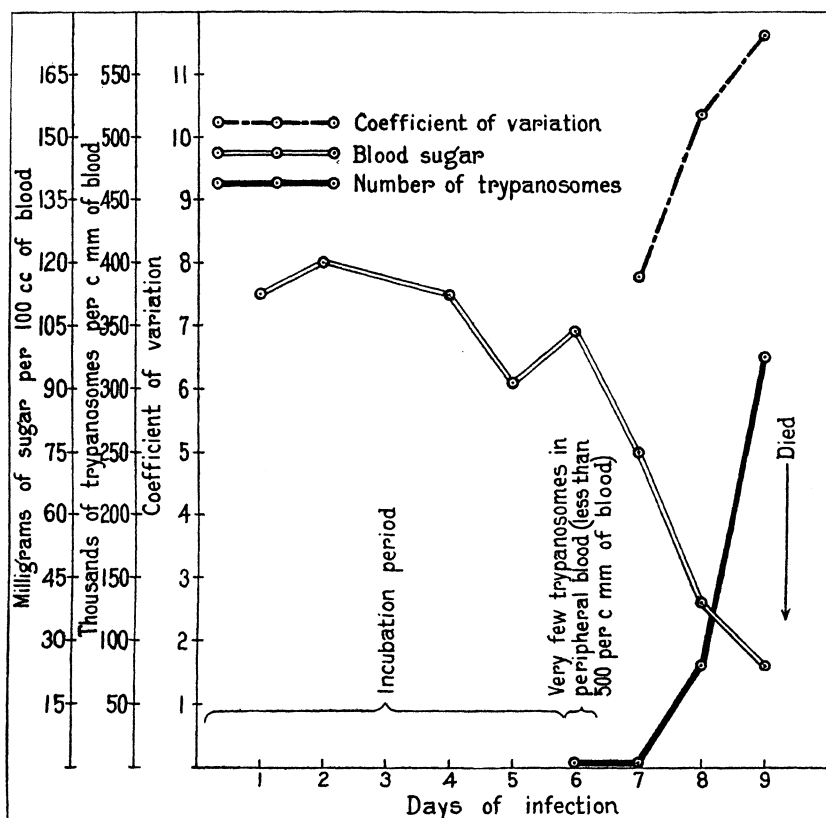


FIG. 4. Blood sugar and the course of infection in cat 1.

never completely disappeared from the peripheral circulation, there were one or two instances during the infection when the organisms, after their successful multiplication, were greatly reduced in numbers. In all of the cases, however, death was the ultimate outcome and this occurred when the number of parasites in the blood had reached a maximum (322,000 to 850,000 trypanosomes per cubic millimeter of blood).

With respect to the blood sugar, the results were also contradictory. In cats 1 and 2 a progressive hypoglycæmia developed soon after the entrance of the organisms into the general circulation. During the incubation period of the infection the sugar readings of each of these two animals averaged a little over 100 milligrams per 100 cubic centimeters of blood; after that time there occurred a gradual diminution so that shortly

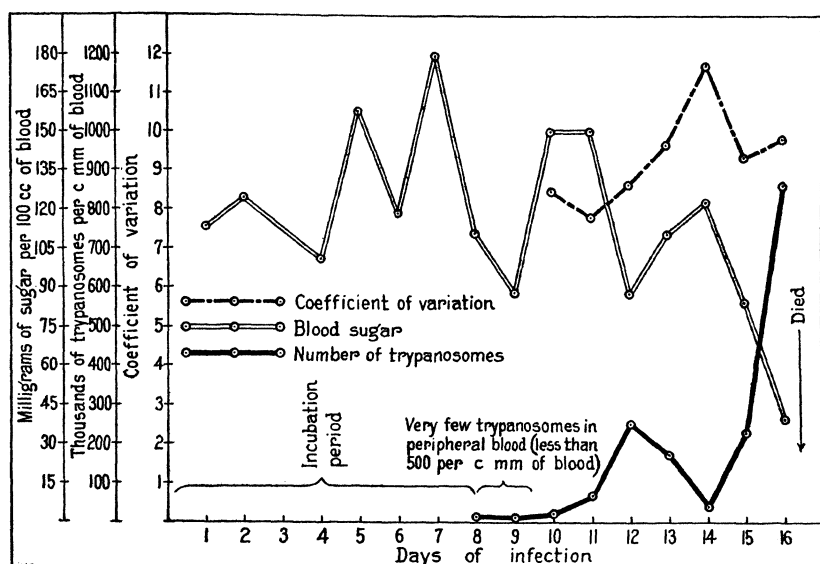


FIG. 5. Blood sugar and the course of infection in cat 3.

before death the readings were only 26 and 34 milligrams, respectively, per 100 cubic centimeters of blood.

The contradictory results obtained in cats would have been difficult to explain had it not been for the following observation. Soon after the appearance of the trypanosomes in the general circulation of cats 1 and 2, these animals began to evacuate bloody fæces, which on examination revealed the presence of numerous coccidial oöcysts (*Isospora bigemina*). These cats had previously been examined and found to be lightly infested with coccidia, but they did not show any symptoms of coccidiosis till after they had been successfully infected with surra. It is to be presumed, therefore, that the trypanosomes, perhaps by lowering the resistance of the host animals, induced the rapid multiplication of the coccidial parasites, as a result of which the cats showed acute symptoms of coccidiosis. It may also be inferred that the two diseases, trypanosomiasis and coccidiosis, must have been jointly responsible in bringing about the condition of progressive hypoglycæmia and causing the early death of cats 1 and 2. Otherwise, trypanosomiasis alone, as shown in the case of cat 3, runs a chronic relapsing course and it either brings about no changes in the dextrose content of the blood or produces only a terminal hypoglycæmia.

Dogs.—Two dogs were inoculated. Incubation period, six to ten days; duration of infection, sixteen to thirty-two days. For the other data, fig. 6 may be consulted.

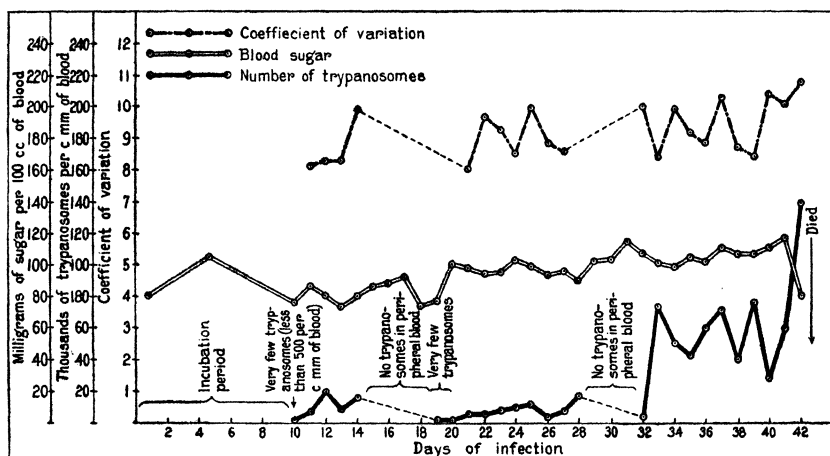


FIG. 6. Blood sugar and the course of infection in dog 1.

It will be seen that in dogs *surra* also runs a chronic relapsing course, the infection being characterized, as in guinea pigs, by intermittent periods, during which no parasites are visible in the peripheral circulation. Towards the end, however, after the resistance of the hosts has apparently been used up, the infection follows a course similar to that which takes place in rats; that is, there is a rapid increase in the number of the organisms and the animals die when that number has reached its maximum (142,000 to 852,000 trypanosomes per cubic millimeter of blood). In this respect the infection in the dog differs from that in the guinea pig, for in the latter death usually takes place when the parasites in the circulation are scanty.

The observations on the blood sugar are similar to those in the other groups of animals. In dog 1 (fig. 6) the sugar readings were between 80 and 111 milligrams per 100 cubic centimeters of blood throughout the infection, while in the other dog there was only a terminal hypoglycæmia.

Horses.—Four horses were infected, but we have complete records on only one of them. Incubation period, four to seven days; duration of infection, thirteen days for horse 2 with complete records. For the other data, fig. 7 may be consulted.

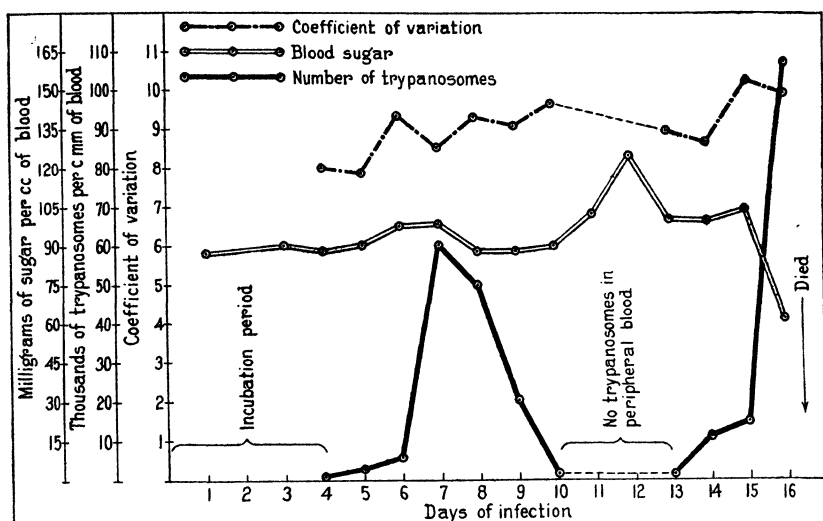


FIG. 7. Blood sugar and the course of infection in horse 2.

It is shown that the character of the infection in the horse is quite similar to that in the dog. It runs a relapsing course, and death takes place when the parasites are most numerous in the circulation.

In common with the other animals studied, the only effect of the infection on the sugar content of the blood was the production of a terminal hypoglycæmia.

SUMMARY AND CONCLUSIONS

The resistance and the blood sugar of rats, guinea pigs, cats, dogs, and horses infected with surra were studied. The resistance was measured according to the method of Taliaferro and Taliaferro (1922), and the sugar determinations were made by the "micro" method of Folin (1928).

In common with the findings of Knowles and Das Gupta (1928), varying degrees of resistance were exhibited by the different animals studied, as indicated by their ability to keep in abeyance for a shorter or a longer period of time the rapid and permanent proliferation of the surra organism. Thus, on the one hand, the rat possesses a low type of resistance, for in this animal the infection runs an acute progressive course, the parasites undergoing a constant increase in number and death taking place when the number of the parasites in the blood has

reached a maximum. The guinea pig, on the other hand, possesses a high type of resistance, for in this animal the infection follows a chronic relapsing course and death usually occurs when the parasites are scanty in the circulation. The resistance of the cat, the dog, and possibly the horse is of an intermediate type, for in these animals the infection is, as in the guinea pig, chronic and relapsing in nature; but, as in the case of the rat, death occurs when the parasites are most numerous in the peripheral circulation.

No evidence was obtained to show that resistance against surra is dependent on the ability of the host animal to maintain a normal blood-sugar content.

In the majority of cases, irrespective of the kind of animal studied, no appreciable changes in the sugar content of the blood were observed during the course of the infection, except at the very end when a terminal or agonal hypoglycæmia was usually detected. In two cats the disease followed an abnormally acute course and was characterized by a progressive hypoglycæmia due, however, to the fact that in these particular animals the infection was complicated with coccidiosis.

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ILLUSTRATIONS

TEXT FIGURES

- FIG. 1. Blood sugar and the course of infection in rat 2.
2. Blood sugar and the course of infection in rat 7.
3. Blood sugar and the course of infection in guinea pig 1.
4. Blood sugar and the course of infection in cat 1.
5. Blood sugar and the course of infection in cat 3.
6. Blood sugar and the course of infection in dog 1.
7. Blood sugar and the course of infection in horse 2.

TREMATODE PARASITES OF PHILIPPINE VERTEBRATES, IV. ECTOPARASITIC FLUKES FROM MARINE FISHES

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THREE PLATES

A heavy mortality among the marine fishes in the aquarium of the Bureau of Science in Manila was registered recently and attempts to discover the cause resulted in the finding by Mr. C. Martin, of the division of fisheries, Bureau of Science, of a small trematode on the gills of affected fishes. Because of the suspicion that the fluke might have been responsible for this mortality, the writer was requested to look over the remaining fishes in the aquarium and to determine their parasites, if any be encountered.

With the coöperation of Mr. Martin, representatives of the following three species of fishes, which, at the time of our visit to the aquarium, showed signs of disease, were examined: *Anyperodon leucogrammicus* (Valenciennes) Bleeker, *Teuthis virgata* (Cuvier and Valenciennes), and *Lutianus lioglossus* (Bleeker). From the gills of these fishes, three types of monogenetic flukes, representing three genera, were collected. Among them is a minute form which, in view of its taxonomic position and other considerations, is most probably the suspected parasite. It is a member of the genus *Ancyrocephalus* Creplin, 1839, and is, therefore, very closely related to the known pathogenic ectoparasitic trematodes of fishes in Europe and in the United States. It was present in predominating numbers on the gills of all the fishes examined. The infested organs were much congested and showed numerous punctiform hæmorrhages, produced no doubt by the hooks of the parasite.

ANCYROCEPHALUS MANILENSIS sp. nov. Plate 1, figs. 1, 2, and 3.

This is a very minute form, differing in that respect from other species of *Ancyrocephalus* and in particular from *A. teuthis* (MacCallum, 1915) Johnston and Tiegs, 1922, described

from *Teuthis hepatus*, a host that is related generically to one of the fishes from which the present parasite was collected. It further differs from *A. teuthis* in the extent of its vitellaria and in the shape of its ovary.

*Description.*¹—Body elongate, 0.14 to 0.23 millimeter in length by 0.04 to 0.06 millimeter in width across testis; anterior end somewhat conical, with conspicuous lateral head lobes; posterior end of body proper more or less truncated, separated from caudal disc by a very slight constriction; cuticle smooth. On each side of the head, in the region of the cephalic lobes, are the terminals of three ducts, which are probably those of mucous glands that are commonly present in this group of trematodes, but the position of which could not be determined in the specimens available. Behind these duct terminals or immediately in front of the pharynx on each side of the median line, are two pairs of eyes, of which the posterior pair is larger. At the posterior end of the body is the caudal disc, 0.038 to 0.044 by 0.050 to 0.065 millimeter in size and provided with two pairs of principal central hooks and two pairs of minute marginal spines. The principal hooks are of almost the same characteristic shape (Plate 1, Fig. 2) and size, being about 0.045 millimeter in total length; they all terminate distally into fine recurved points, those of the dorsal pair being normally directed outwards and those of the ventral pair inwards. Each pair of hooks is joined together by a transverse piece; that of the dorsal pair is only slightly depressed in the center and that of the ventral pair is much bent and presents the appearance of an inverted yoke; each hook is supplied with a muscular bundle originating from the body proper.

Digestive system.—The mouth is a minute opening at the extreme anterior end; it communicates posteriorly through a narrow longitudinal passage with the relatively large pharynx. The latter is globular in shape, 0.013 to 0.017 millimeter in diameter, and located at about 0.030 millimeter from the anterior end. The oesophagus is very short, and divides immediately into two simple intestinal cæca that reach posteriorly to near the origin of the caudal disc.

Male reproductive organs.—The single testis is a relatively large, elongate organ, 0.035 to 0.040 by 0.020 to 0.030 millimeter

¹ The descriptions of this and the other forms dealt with in this paper are based on stained specimens that were killed and preserved without the use of pressure.

in size, located between the two intestinal branches immediately behind the equator of the body. The vas deferens is short and is dilated at about the middle of its length to form a sort of seminal vesicle; distally, it is modified into a copulatory organ, the ejaculatory duct, which, before reaching the common genital pore, passes through a roundish structure, the bulbus ejaculatorius. The common genital pore is in the median line, a short distance behind the intestinal bifurcation.

Female reproductive organs.—The ovary is equatorial in position, pretesticular, more or less round in shape, 0.017 to 0.025 by 0.017 to 0.020 millimeter in size. The uterus is short and opens beside the ejaculatory duct into the common genital pore. The vaginal opening is located on the right side at a level nearly equidistant between the pharynx and the ovary. The vitellaria are in the form of very minute and closely set follicles, located extracæcally for the most part and extending from the anterior level of the pharynx to the posterior limit of the intestines; anteriorly the vitelline glands of one side are separated from those of the opposite side, but posteriorly they are continuous. The transverse vitelline ducts and their reservoir are located on the dorsal surface at a level equidistant between the ovary and the bulbus ejaculatorius; the oötype complex is found immediately in front of this level. Only one egg is present in the uterus at a time and is usually not kept there long, for which reason the uterus is frequently encountered empty and collapsed. The egg (Plate 1, fig. 3) is asymmetrical in shape and about 37 by 28 microns in size; it is provided at one pole with a filament of variable length and diameter.

Specific diagnosis.—*Ancyrocephalus*: Very small, elongate, 0.14 to 0.23 by 0.04 to 0.06 millimeter in size; anterior end bluntly conical, with conspicuous cephalic lobes and containing the terminals of three pairs of ducts; posterior attaching disc well developed, not very sharply marked off from body, and supplied with two pairs of characteristically shaped central hooks and two pairs of marginal minor spines; ovary and testis median, at third fourth of body length, the former immediately in front of latter; ovary more or less globular in shape, 0.017 to 0.025 by 0.017 to 0.020 millimeter in size; testis elongate, 0.035 to 0.040 by 0.020 to 0.030 millimeter in size; copulatory organ with bulbus ejaculatorius; common genital pore median, immediately behind intestinal bifurcation; vitellaria separate anteriorly, continuous posteriorly, extending from anterior level

of pharynx to termination of intestines; egg asymmetrical, filamented, 37 by 28 microns in size.

Hosts.—*Teuthis virgata* (type host), *Lutianus lioglossus*, *Anyperodon leucogrammicus*.

Location.—Gills.

Locality.—Manila, P. I.

Type specimens.—Philippine Bureau of Science parasitological collection No. 49.

TETRANCISTRUM LUTIANI sp. nov. Plate 2, figs. 1, 2, 3, 4.

This parasite differs from *Tetrancistrum siguni* Goto and Kikuchi, 1917, the type and until now the only species of the genus, in being smaller, in the shape of its pharynx, which is globular instead of being elongated, and in having no lateral secondary intestinal cæca.

Description.—Body small, elongate, with three transverse constrictions; namely, an anterior one separating the head from the body proper, a middle one at or in front of middle of body length, and a posterior one separating the attaching disc from the body proper; length 0.40 to 0.50 millimeter, width across testis 0.14 to 0.17 millimeter; cuticle smooth. Anterior end with two pairs of lobes, into each of which leads a small duct probably from certain glands, the position of which could not be determined. At the posterior end is the attaching disc, which is transversely oval in shape and 0.038 to 0.040 by 0.070 to 0.080 millimeter in size; it is devoid of marginal spines, but is provided with two pairs of central hooks that are dissimilar in shape and size (Plate 2, fig. 3). The ventral pair of hooks average about 0.086 millimeter each in length and have distinctly biramous basal portions so that they appear asymmetrically V-shaped; they are connected together by a chitin piece, the extremities of which are rolled in. The dorsal pair of hooks average about 0.075 millimeter each in length and their basal portions are not biramous, their accessory pieces being short and almost stumpy; they are connected together by a slightly bent chitin piece.

Digestive system.—The small mouth is terminoventral in position and leads through a narrow passage into the globular pharynx. The latter is 0.040 millimeter in diameter and in moderately extended specimens is located about 0.050 millimeter from the anterior end. The oesophagus is very short. The intestinal cæca are simple canals; immediately behind

the testis they unite, after which they again separate and terminate blindly a short distance behind the point of their union.

Male reproductive organs.—The single testis is globular in shape, 0.104 to 0.107 millimeter in diameter, and is postequatorial and immediately postovarial in position, being partly overlapped in ventral view by the ovary. The sperm duct is short and somewhat dilated into a seminal vesicle before joining the chitinous penis; the latter is in the form of a double-walled, hollow, curved tube (Plate 2, fig. 2). The common genital pore is located in the median line, a short distance behind the intestinal bifurcation.

Female reproductive organs.—The ovary is transversely elongate, slightly arched, 0.060 to 0.070 millimeter across; it is immediately postequatorial and pretesticular in position. The uterus is short and opens outside through the common genital pore beside the male terminal organ. Immediately in front of the ovary, the uterus gives off a side branch, the vagina, that opens outside through an opening on the right side of the body, behind the level of the common genital pore. Only one egg is contained in the uterus at a time; it is of characteristic symmetrical shape, 50 by 55 microns in size and is provided at one pole with a filament of variable length and diameter (Plate 2, fig. 4); it is usually laid soon after it is formed, hence it is rare to find a worm with an egg in utero. The vitellaria are well developed, extending from the posterior level of the pharynx to behind the testis, thus surrounding the intestinal cæca more or less completely; they are continuous anteriorly and posteriorly.

The details of the excretory system were not worked out; only two terminal canals with their corresponding openings were observed; these are marginal in position, behind the posterior level of the pharynx.

Specific diagnosis.—*Tetrancistrum*: Body small, 0.40 to 0.50 by 0.14 to 0.17 millimeter in size; pharynx globular; œsophagus very short; intestinal cæca simple, devoid of lateral secondary cæca; caudal disc transversely oval in shape, 0.038 to 0.040 by 0.070 to 0.078 millimeter in size; caudal hooks dissimilar: ventral pair 86 microns long, asymmetrically V-shaped due to distinctly biramous basal portions and dorsal pair 75 microns long, with short accessory piece; egg symmetrical, filamented, 50 by 55 microns in size.

Host.—*Lutianus lioglossus*.

Location.—Gills.

Type specimens.—Philippine Bureau of Science parasitological collection No. 50.

MICROCOTYLE VIRGATARUM sp. nov. Plate 3, figs. 1, 2, 3.

This trematode resembles the large majority of the members of the genus *Microcotyle* P. J. van Beneden and Hesse, 1863, in being symmetrically shaped, but it differs from them in the extent of its intestinal cæca that reach into the posterior region of the caudal disc. According to the available literature, only *M. sciaenae* Goto, 1895, has intestines extending thus far posteriorly, but that species differs from the present form in being larger and asymmetrically shaped and in the possession of a larger number of posterior suckers.

Description.—Body elongate, tapering towards both extremities, 1.60 to 1.90 millimeters in length by 0.30 to 0.35 millimeter in maximum width; cuticle smooth. Caudal disc, 0.7 millimeter long or more than one-third of total body length, not very distinctly separated from body proper; it bears on both sides rows of minute suckers, forty-eight to fifty of them on each side and measuring about 0.030 by 0.045 millimeter. The structure of these posterior suckers (Plate 3, fig. 3) has been described by Goto (1895).

Digestive system.—The mouth is ventroterminal in position and contains in its cavity a pair of suckers. Each of these anterior suckers is oval in shape, 0.055 by 0.040 millimeter in size, and contains a membranous septum. The pharynx is very small, 0.023 by 0.027 millimeter in size; the œsophagus is very short, bifurcating immediately into two long intestinal cæca that extend to the posterior end of the body. Each intestinal cæcum contains, to as far as the beginning of the caudal disc or slightly beyond that level, both external and internal branches, which in turn contain secondary branches; in the rest of the region of the disc the cæca contain only primary external branches.

Male reproductive organs.—The testes are small transversely oval glands, 18 to 20 in number, arranged in two longitudinal rows in the middle of the second third of the body length. The vas deferens runs a slightly tortuous course in the median line from in front of the anterior testes to an S-shaped thick-walled organ, the penis, that leads into the common genital pore. The

latter is in the median line, in the center of a triangular genital sinus, about 0.15 millimeter from the anterior end.

Female reproductive organs.—The ovary is median, pretesticular, between the anterior and middle thirds of the body length; it is strongly arched, with one extremity rounded and larger than the other. The oviduct arises from the slender arm of the ovary, is directed posteriorly, becomes enlarged into an oötype into which the unicellular shell glands discharge their contents, makes a right-angled turn, gives off the genitointestinal canal, turns anteriorly and is continued as the uterus. The latter opens into the common genital pore beside the terminal male reproductive organ. The vaginal opening is in the median line, at about twice the distance from the anterior end of the worm to the common genital pore. The vaginal canal is short and soon divides into two posterior branches that become continuous with the principal vitelline ducts. The latter, continuing posteriorly, meet in the median line at the region of the ovary to form a relatively large, elongate vitelline reservoir, the duct of which joins the oviduct at about midway between the oötype and the point of origin of the genitointestinal canal. The vitellaria are in the form of minute follicles, extending from immediately behind the level of the common genital pore to some distance behind the testes; they are mostly lateral in position and surround the corresponding lengths of the intestinal cæca; anteriorly the glands of one side are separate from those of the other side, while posteriorly they are continuous.

Specific diagnosis.—*Microcotyle*: Body elongate, symmetrical, tapering towards both ends, 1.60 to 1.90 by 0.30 to 0.35 millimeter in size; caudal disc more than one-third of body length, not very distinctly separated from body proper; posterior suckers forty-eight to fifty in number on each side of disc; anterior suckers in mouth cavity each with membranous septum; pharynx small; œsophagus very short; intestinal cæca long, reaching to near posterior end of body, with external and internal branches; testes small, oval, eighteen to twenty in number, in two longitudinal rows, at middle third of body length behind ovary; penis S-shaped, thick-walled; common genital opening in center of triangular genital sinus, 0.15 millimeter from anterior end; ovary strongly bent, between anterior and middle thirds of body length; distance of vaginal opening from anterior end twice that from anterior end to common genital

pore; vitellaria separate anteriorly, continuous posteriorly, extending from immediately behind level of common genital pore to some distance behind testes.

Host.—*Teuthis virgata*.

Location.—Gills.

Locality.—Manila, P. I.

Type specimens.—Philippine Bureau of Science parasitological collection No. 51.

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ILLUSTRATIONS

[Drawn by Mr. V. V. Marasigan under the direction of the author.]

ABBREVIATIONS

<i>as</i> , anterior sucker.	<i>ov</i> , ovary.
<i>bej</i> , bulbus ejaculatorius.	<i>pe</i> , penis.
<i>cd</i> , caudal disc.	<i>ph</i> , pharynx.
<i>du</i> , terminal duct.	<i>ps</i> , posterior sucker.
<i>es</i> , eye spot.	<i>t</i> , testis.
<i>gic</i> , genitointestinal canal.	<i>ut</i> , uterus.
<i>gp</i> , common genital pore.	<i>vd</i> , vas deferens.
<i>h</i> , hook.	<i>vid</i> , vitelline duct.
<i>int</i> , intestine.	<i>vit</i> , vitelline glands.
<i>mo</i> , mouth.	<i>vo</i> , vaginal opening.
<i>mu</i> , muscle supplying hook.	<i>vr</i> , vitelline reservoir.

PLATE 1. *ANCYROCEPHALUS MANILENSIS* SP. NOV.

- FIG. 1. Entire worm, dorsal view.
2. Caudal hooks, dorsal view.
3. Egg.

PLATE 2. *TETRANCISTRUM LUTIANI* SP. NOV.

- FIG. 1. Entire worm, ventral view.
2. Penis, lateral view.
3. Caudal hooks.
4. Egg.

PLATE 3. *MICROCOTYLE VIRGATARUM* SP. NOV.

- FIG. 1. Entire worm, ventral view.
2. Terminal portion of male reproductive system, showing penis, common genital pore, and genital sinus.
3. A posterior sucker.

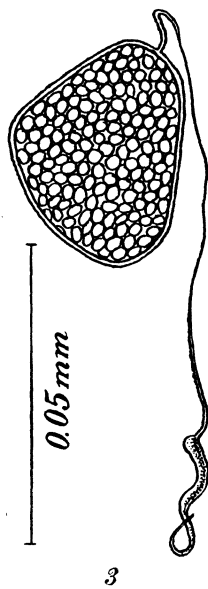
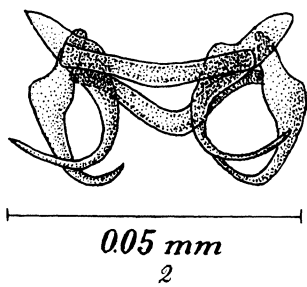
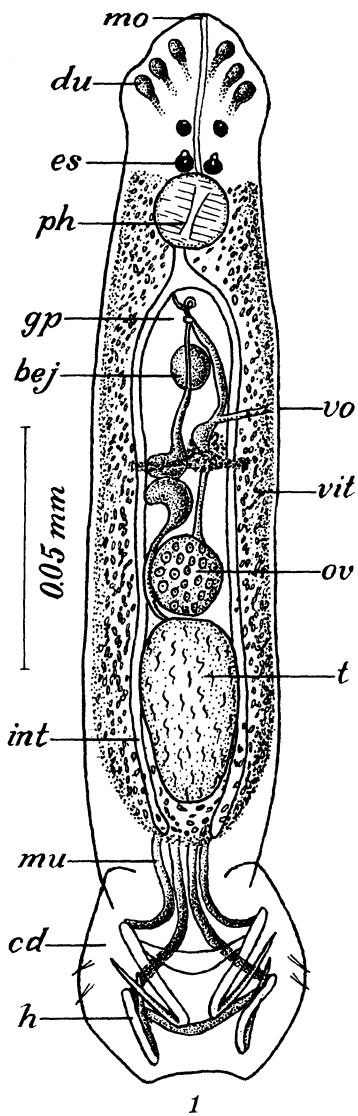


PLATE 1. ANCYROCEPHALUS MANILENSIS SP. NOV.

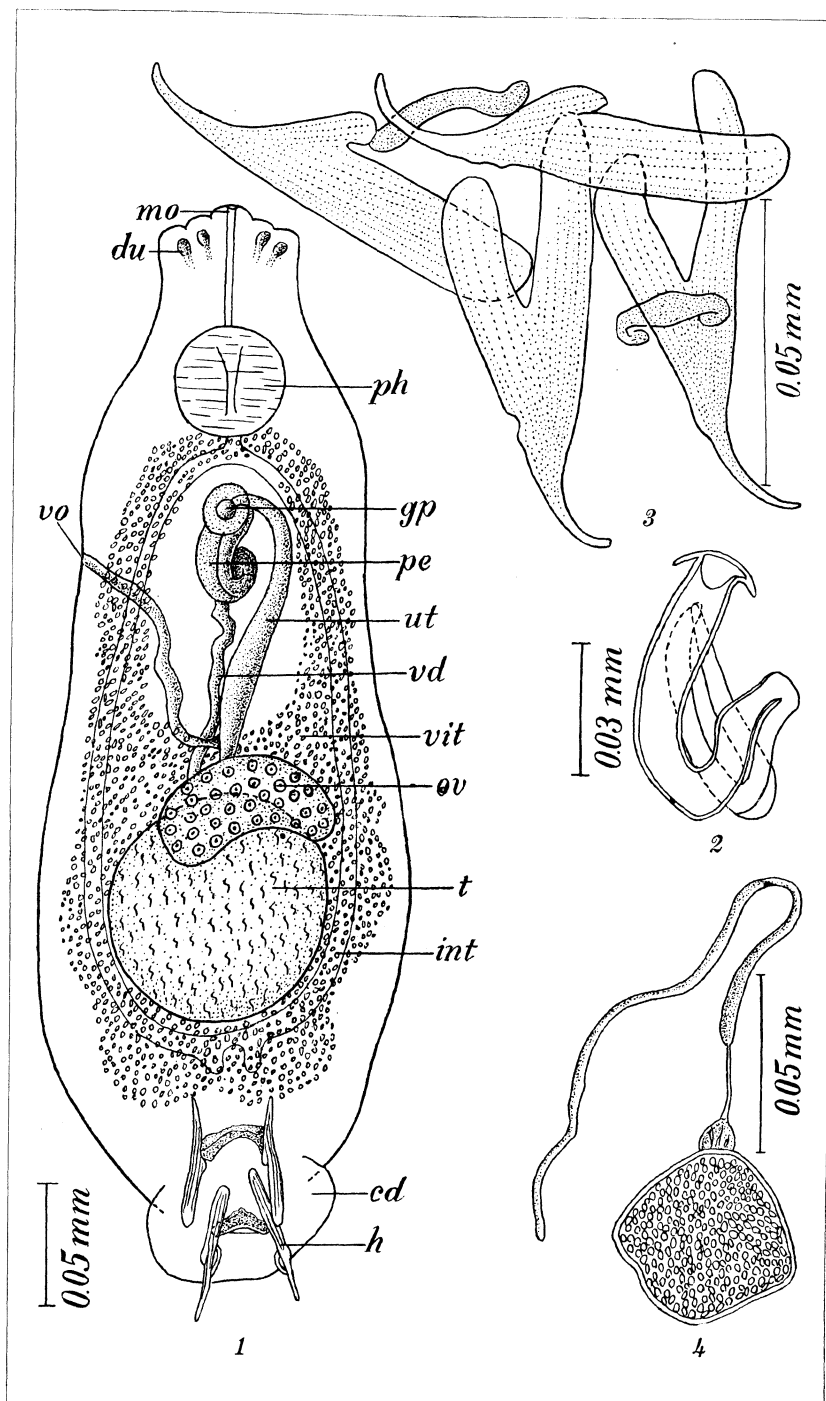


PLATE 2. TETRANCISTRUM LUTIANI SP. NOV.

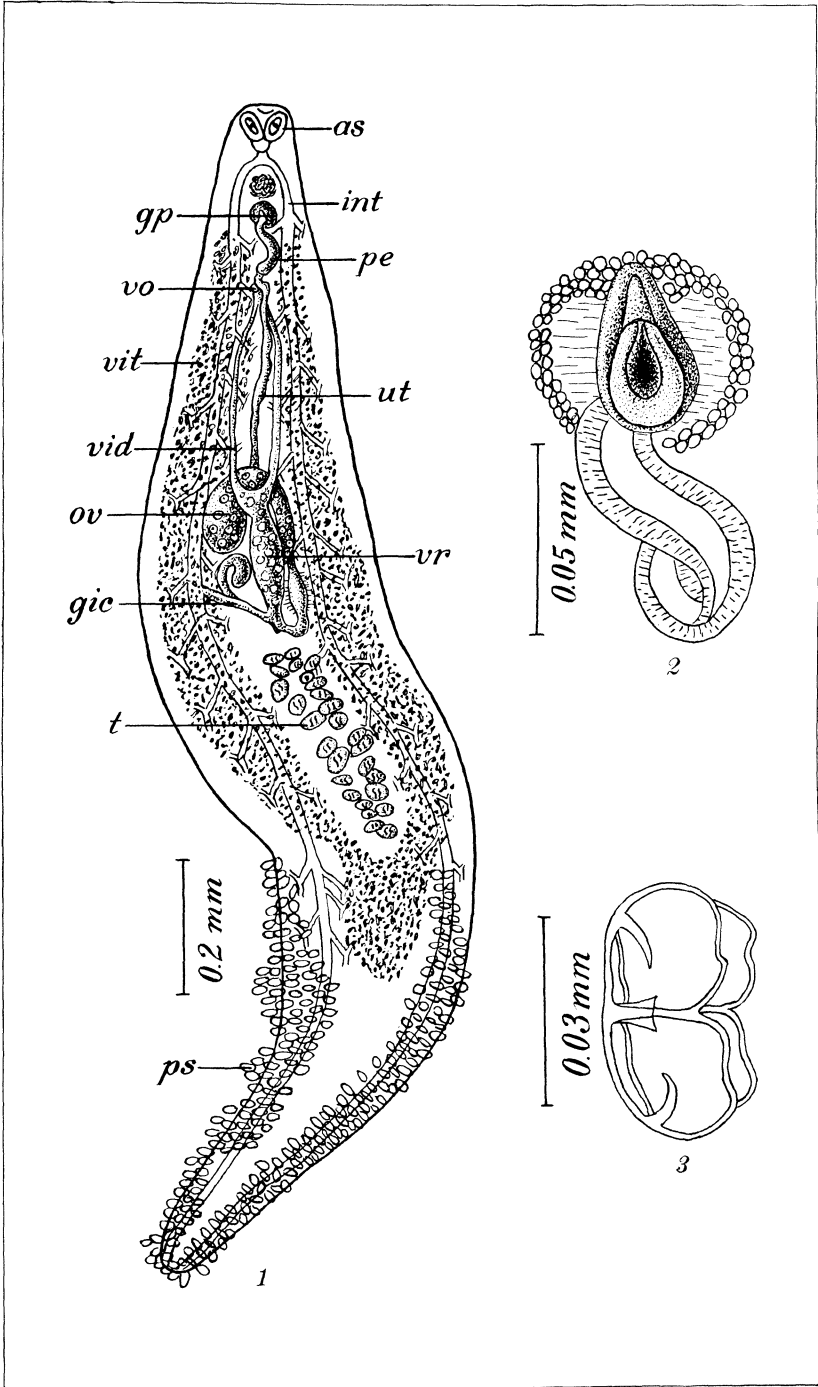


PLATE 3. MICROCOTYLE VIRGATARUM SP. NOV.

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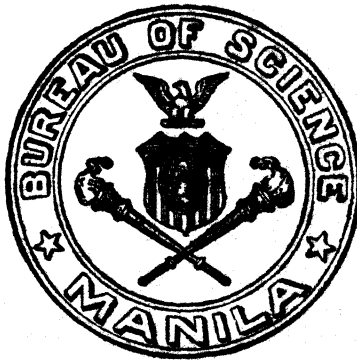
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THE PHILIPPINE JOURNAL OF SCIENCE

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JUNE, 1931

No. 2

THE WATER SUPPLY OF MANILA FROM UNDER- GROUND SOURCES

By LEOPOLDO A. FAUSTINO

*Chief Geologist, Division of Geology and Mines
Bureau of Science, Manila*

THREE PLATES AND THREE TEXT FIGURES

INTRODUCTION.

GEOLOGICAL FORMATIONS.

SOURCE AND MOVEMENT OF GROUND WATER.

OCCURRENCE OF GROUND WATER.

DEVELOPMENT AND UTILIZATION.

SUMMARY AND CONCLUSIONS.

LOGS OF WELLS.

INTRODUCTION

The water supply of Manila comes from two main sources; namely, the water system of the Metropolitan Water District and artesian wells. For washing, bathing, and other domestic needs the people of Manila use the water of the Metropolitan Water District, but for drinking purposes they show a decided preference for artesian-well water. It should be stated, however, that chemical and bacteriological analyses of tap water of the Metropolitan Water District have indicated that it is just as suitable for drinking purposes as water from the artesian wells. There are, of course, residents of Manila who use distilled water from the ice plants.

The artesian wells represent the main source of supply of the general public for their drinking water. There are at present twenty public artesian wells within the boundary limits of the City of Manila and about an equal number of private artesian

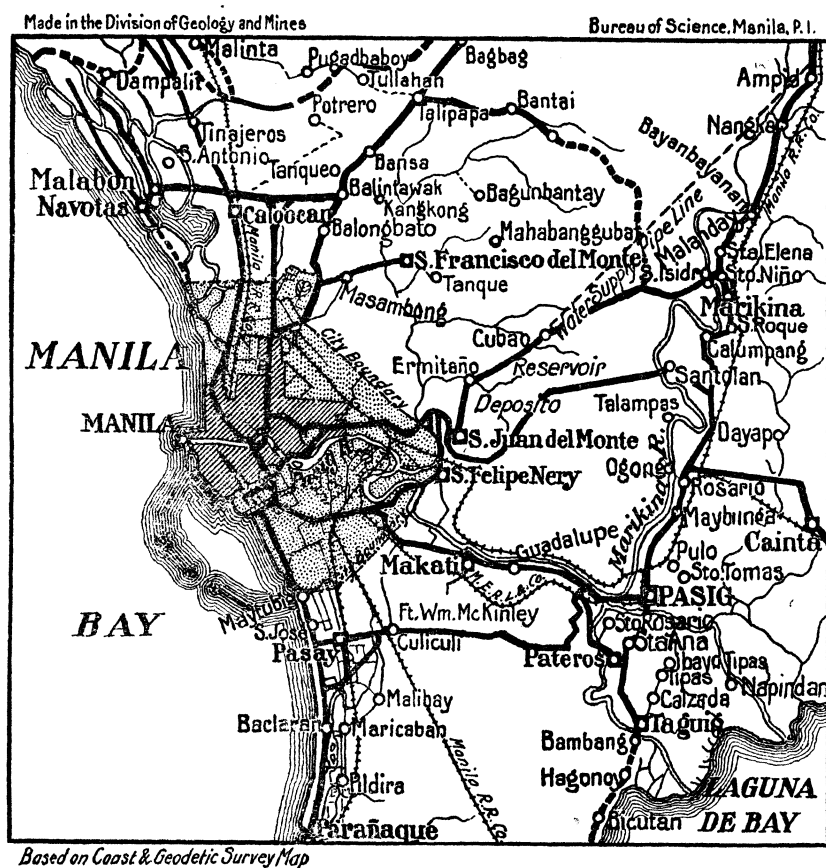


FIG. 1. Manila and neighboring towns.

wells. The public artesian wells located in the more-populous districts are crowded with water carriers from early morning to almost midnight, and many of the private artesian wells are likewise busy all day either filling demijohns of customers or their own demijohns for delivery to residences. It is estimated that these artesian wells, together with those in the vicinity of Manila, numbering more than one hundred, are supplying about 2,700 cubic meters (712,800 gallons) of drinking water per 12-hour day. It is the purpose of this article to describe the geologic occurrence of this artesian water, which is the source of drinking water for the majority of the population of Manila and neighboring districts. For the chemical analyses of the artesian water the reader is referred to the article by Aguilar and Ocampo, following in this issue.

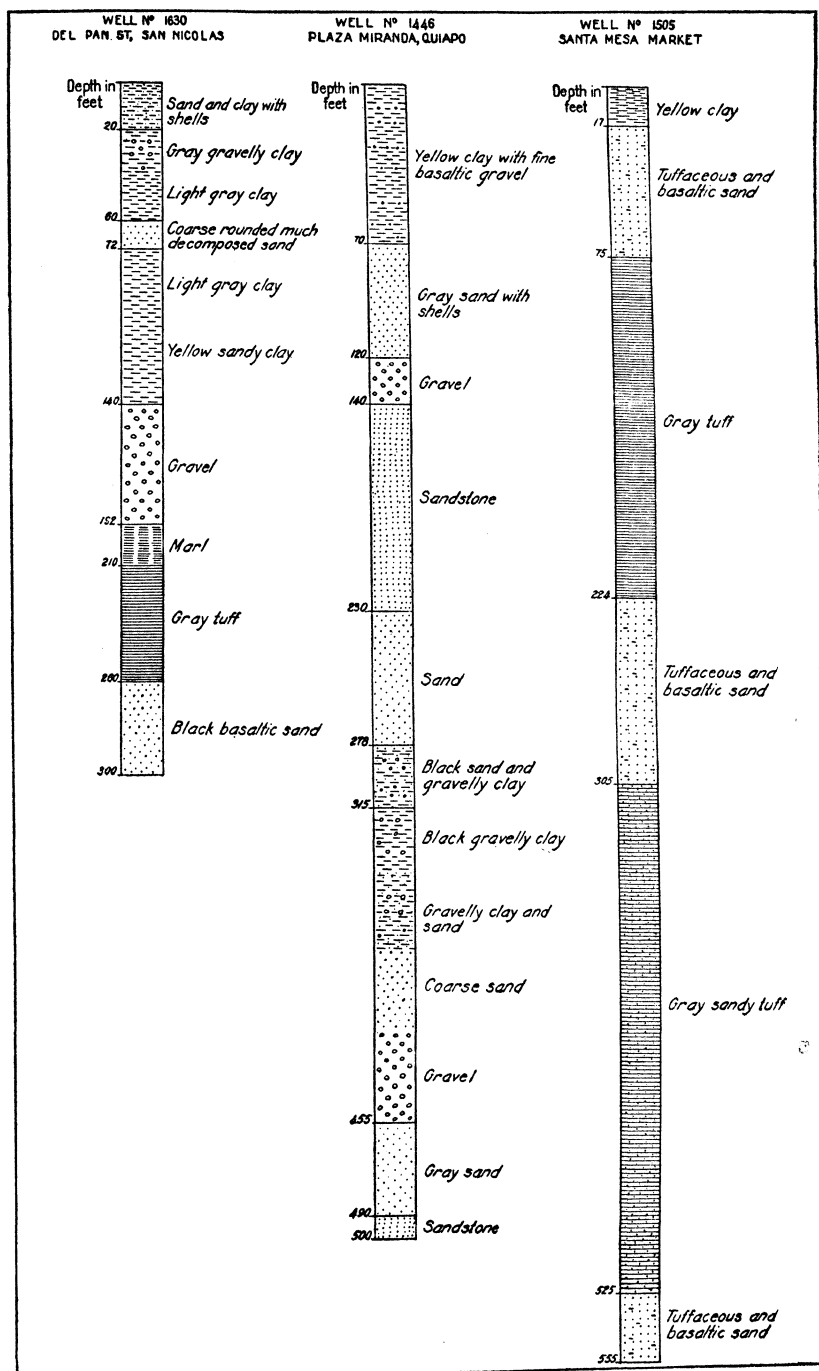


FIG. 2. Sections of wells in Manila.

The writer wishes to acknowledge with thanks the help given him by Mr. F. W. McCaw, superintendent of the artesian-well division, Bureau of Public Works, who allowed unrestricted use of the information and artesian-well data he has available.

GEOLOGICAL FORMATIONS

The surface formations of the City of Manila consist in the main of an unconsolidated series of sands, clays, and muds, alluvial and littoral deposits. These overlie a basement of more-consolidated series of volcanic sand, dust, and ash, and intercalated beds which constitute the Guadalupe-tuff formation. The tuff formation outcrops on the outskirts of the city; it occupies the highest land and most of the suburban districts.

The Guadalupe tuff.—This formation consists of gray, brown, or buff-colored deposits of varying thicknesses. The beds are clearly stratified—some layers are from 10 to 15 centimeters thick, and consist of very fine material, which is sandy or shaly; others are from 3 to 4 meters or more in thickness, and are of coarser material, which is at times gravelly and full of pumiceous masses ranging from 3 to 5 centimeters in diameter; still others consist of uniform material and attain considerable thickness. None of the beds is persistent for any distance, and none can be recognized and used as a datum plane. Some of the thinner beds appear and disappear at intervals. From the exposures on the sides of small hills, road cuts, and river banks it is gathered that the materials were thrown from volcanic orifices at periodic intervals. During periods of rest the finer material settled to form the finer beds. Apparently, the materials were deposited in water, as bands of fine material such as form only under water-settling conditions are found. Occasional beds of marine sand are intercalated in the tuff, as well as some strata with waterworn gravels and fine pebbles.

No marine fossil has been identified as most of the forms encountered in the drill samples are small pieces of shells and diligent search for other fossils has not been made. It is reported by Adams¹ that "Occasionally a log of wood has been encountered in drilling, and plant remains, fish teeth (fig. 3) and one mammalian tooth have been found in the beds."

From time to time bits of wood have been brought up from the bottom of artesian wells at depths of 100 meters or more, but the logs could have been carried to the bottom of the sea

¹ Philip. Journ. Sci. § A 5 (1910) 73.

by running water. However, on the higher portion of the tuff formation, plant remains and perfect leaf impressions have been found, which would seem to indicate terrestrial conditions. The fish teeth reported by Adams are probably not shark's teeth, which are generally pointed and have a cutting edge. The figures that he presented are apparently grinding teeth. Specimens in the collection of the division of mines, Bureau of Science, presumably shark's teeth, are now labelled, "Mammal Artiodactyl tooth. W. Granger." On the basis of structural relations of the tuff to the other formations in the region rather than on the meager fossil data, the Guadalupe-tuff formation has been assigned to the Pliocene.

Quaternary alluvium.—These beds are Quaternary deposits of Recent age and occupy most of the low ground. At depths of 1 meter or more marine shells are encountered. Some of these deposits are so recent that they have not had time to leach their salt content. The salt water from Manila Bay has easy penetration through these beds, which represent the mingling zone of fresh water and salt water; in fact, it is the brackish-water zone. These sands, clays, and muds, alluvial and littoral deposits, have no ap-

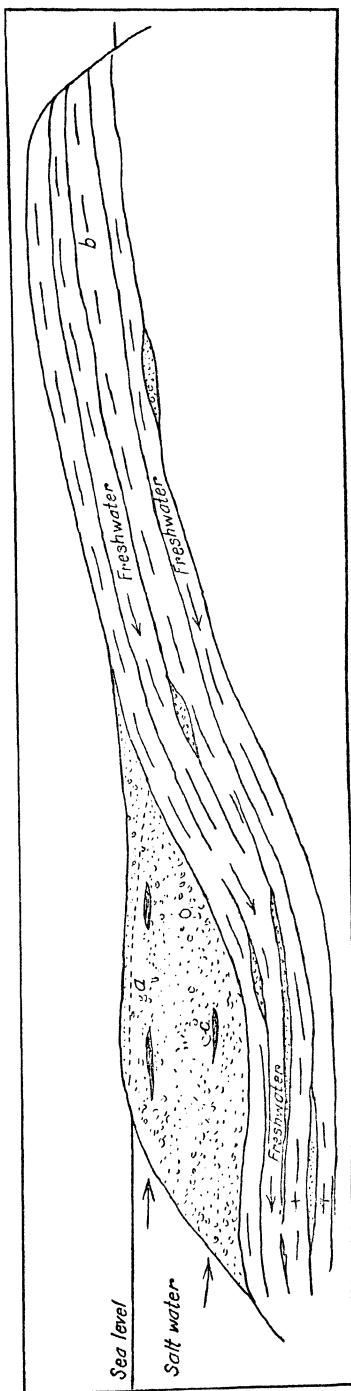


FIG. 3. Geologic section east and west across Manila and vicinity, diagrammatic; showing artesian conditions; a, alluvium; b, tuff; c, impervious material.

parent stratification and are simply loose unconsolidated materials formed by sediments brought down by the rivers, particularly in times of flood, and reworked by the waves and other agencies.

SOURCE AND MOVEMENT OF GROUND WATER

The main source of the ground water is the rainfall. It may be said that practically all the ground water under the City of Manila comes from precipitation upon the regions north and east of Manila. For purposes of this paper it is considered that the Mariquina Graben and the country to the east, as well as Laguna de Bay, are not contributing a great amount to the underground water of the City of Manila, although it is known that there are at least seepages from this area and that some of the deep wells may be getting water from this source. The drainage basin of Manila and neighboring districts is the area bounded on the north by the boundary line between Bulacan and Rizal Provinces, on the east by Mariquina River and Laguna de Bay, and on the south by a line drawn from Parañaque, Rizal, east to Laguna de Bay. This area contains approximately 350 square kilometers of territory, but for the purposes of this paper only 135 square kilometers of surface is considered. The records of the Weather Bureau show that from 1865 to 1923 the average rainfall for Manila was 2,018.7 millimeters. Based on the annual average rainfall and drainage basin of 135 square kilometers, the amount of rain water falling during the year is calculated to be about 270,000,000 cubic meters.

According to Van Hise,² of the water which falls on the land substantially one-half soon evaporates, about one-sixth is consumed by the plants or joins the underground water, and the remaining one-third passes into the rivers and goes into the sea. Lindgren, however, in his report on the water resources of Molakai, Hawaiian Islands, says in part:³

A part of this rainfall is carried off by evaporation, another part by the streams, while a third and largest part sinks into the ground and gradually finds its way to the ground water, which permanently saturates the rocks below a certain level.

The tuff formation, which covers most of the drainage area under discussion, is very porous, but in order to be conservative the estimate is made that only one-fifth of the total rainfall

² Conservation of Natural Resources in the United States, MacMillan (1927) 107.

³ U. S. Geol. Surv. Water-supply Paper 77 (1903) 26.

joins and forms part of the underground water. It would not be surprising when records become available to find that more than one-fifth of the water goes underground, at least for this particular area. The total amount of water per year that goes to form part of the underground supply is estimated at 54,000,000 cubic meters, or approximately 14,000,000,000 gallons. At the present time it has been calculated that the artesian wells of the City of Manila and neighboring districts are supplying water at the rate of 2,700 cubic meters per 12-hour day, or 985,500 cubic meters per year. This calculation is based on the actual capacity of the eighty wells in Manila and neighboring municipalities reported by Aguilar and Ocampo as 2,498 liters per minute, or an average of 31 liters per minute per well, plus twenty-two private wells in Manila and about eighteen wells outside of Manila, all assumed to have the same capacity. Of the 54,000,000 cubic meters available underground, there is being utilized less than a million cubic meters. In other words, the capacity of the reservoir rock below and the source is barely utilized. An increase of ten times the present number of artesian wells would still leave plenty to spare.

Water falling on the ground fills the pore spaces between grains or particles and cavities in the rock formations. As more water falls all the voids and pore spaces and all the cavities begin to be saturated. There is a certain level beneath the surface below which there is complete saturation. This level, which follows more or less the topography of the surface, is known as the ground-water table, or simply the water table. The ground water moves under the influence of gravity from higher levels to lower levels. Ground water on the higher portions of Manila and environs moves downward and outward until it reaches the lower portions of Manila and either discharges into the small streams or into Manila Bay or remains underground. It is natural to suppose that there is a lot of movement on the higher levels or in the higher regions north and east of Manila and that under Manila the ground water has little or no movement and is naturally sluggish. As the ground water in the higher outlying districts has been moving constantly it has not been able to dissolve as much other material as the standing ground water in the lowland areas. The sluggish, practically still water under the City of Manila has more time and opportunity to dissolve materials than the water moving downward from the higher levels. The results of chemical analyses of the water were conclusive in their testimony. All the

wells in the higher outlying districts have less total solids than those in the lowland areas of the City of Manila.

OCCURRENCE OF GROUND WATER

In a humid country like the Philippines the ground-water table is near the surface and during the rainy season in Manila it is at the surface. There are several fresh-water-bearing strata under the City of Manila, but apparently the most important ones all belong to the tuff series. The first stratum from which fresh water is obtained is the one lying beneath the soil and consists of fine sand and gravel mixed with clay. The water available from this source is unsanitary and is insignificant in quantity, due to the fact that it represents merely seepages from neighboring areas and at times is only a thin sheet buoyed up by salt water from Manila Bay.

The ground water of importance is contained in the tuff series and in the tuffaceous sand and other sands. The first water-bearing stratum of these series that has yielded considerable water is met with at about 100 meters below the surface of Manila, which is about a meter above sea level, and from this depth down to about 350 meters water has been obtained at more or less regular intervals. The deepest well in Manila at the present time is the Manila Railroad Company well at Tutuban Station.

The tuff series outcrops to the north and east of Manila and dips gently to the west to Manila Bay. The series consists of beds of very fine material, sometimes impervious, and beds of coarser, and often porous material. The porous beds admit water and are the water-bearing strata. In the upland areas north-east of Manila there are two water-bearing beds; one at a depth of between 60 and 80 meters and one between 120 and 150 meters. The intervening zone is a dry bed. The porous beds extend downward and westward to Manila Bay and represent the water containers. They may have split at their lower portions and some parts may have become impervious, or certain portions may have formed structures that will not permit water to pass through. The subsurface conditions under the City of Manila are such that fresh water may be expected below an impervious stratum, which would shut off the salt water, at depths of 100 meters or more. The salt water above 100 meters, sometimes reaching to greater depths, has saturated the voids and pores of the sand, gravel, littoral, and other material, and

is the main source of contamination, either through excessive pumping or defective casings.

DEVELOPMENT AND UTILIZATION

The ground water under the City of Manila is made available by means of wells, either dug, driven, or drilled. Dug wells are generally shallow, usually not over 20 feet deep, sometimes rimmed at the opening with tuff blocks; the water is lifted by means of rope and bucket. There are very few of these wells now in use, as most of them have either been condemned by the Bureau of Health or voluntarily abandoned by their owners. The remains of some of the wells can still be seen at the back or side of some of the old houses and represent mere relics of the past. Driven wells are a little deeper than dug wells, and are constructed by driving into the ground a small pipe with a drive point. They are driven with a sledge hammer or special driving machinery, sometimes homemade. They are generally less than 30 meters in depth and represent an intermediate type between dug wells and artesian wells.

Artesian wells in the City of Manila are generally 100 meters or more in depth. The casings used are 10, 8, 6, and $4\frac{1}{2}$ inches in diameter. They are usually drilled by the churn method. Most of the wells are pumping. As a matter of fact, from 1904 to 1929, inclusive, only three flowing wells have been encountered and all these have ceased to flow and are now pumped. The capacity of these wells varies from 6 to as much as 85 gallons per minute.

Some of the wells have been abandoned on account of contamination by salt water. There are differences of opinion regarding the source of this contamination. Opponents of artesian-well drilling point to what they term inadequate supply. It has been shown elsewhere in this article that not only is there an adequate supply but that more than the same number of wells now existing can be drilled. It is admitted that drillers have encountered salt water at different intervals and that sometimes fresh water and salt water have been brought up alternately in the course of drilling operations, but in the opinion of F. W. McCaw, superintendent of artesian wells, Bureau of Public Works, the salt water comes from the overlying salt-water-bearing strata and is drawn through the bottom of the loose casing by pumping from above. All the wells drilled in Manila have brought up fresh water at the beginning and only

TABLE 1.—Successful artesian wells drilled in the City of Manila from 1904 to January 23, 1930.

[Data furnished by the artesian-well section, Bureau of Public Works.]

Well No.	Location; street or barrio.	Depth.	Diameter of casing.	Capacity in gallon per minute.	Date completed.	Cost.
		<i>Feet.</i>	<i>Inches.</i>			<i>Pesos.</i>
D-1.....	Engineer Island.....	582		P. 28.....	Dec. 31, 1904	4,855.13
D-2.....	Singalong Farm.....	606		P. 78.....	Jan. 31, 1905	3,381.14
D-431.....	Bureau of Science.....	585	10	P. 30.....	Sept. 16, 1912	3,632.00
D-454.....	Philippine General Hospital.....	450	10	P. 85.....	Oct. 10, 1912	1,174.99
D-518.....	Government Ice Plant.....	751	6; 8	P. 25.....	Sept. 11, 1913	6,239.31
D-1396.....	Santa Ana, Plaza Hugo.....	543	6	P. 6.....	Sept. 8, 1919	5,076.64
D-1433.....	Calle Jeaus, Pandacan.....	470	6	P. 10.....	Nov. 6, 1919	4,473.30
D-1446.....	Plaza Miranda, Quiapo.....	500	6	P. 10.....	Dec. 20, 1919	7,054.54
D-1456.....	Magdalena Street, Trozo.....	847	6	P. 44.5.....	Feb. 15, 1920	7,964.99
D-1479.....	San Lazaro, Calle Blumentritt.....	322	6	P. 60.....	Feb. 27, 1920	4,463.73
D-1505.....	Santa Mesa Market.....	555	6	P. 9.....	Mar. 27, 1920	4,454.93
D-1528.....	San Lazaro Hospital.....	880	4.5; 8	P. 50.....	June 12, 1920	7,256.26
D-1544.....	Manila Hotel.....	427	8	P. 60.....	June 15, 1920	6,315.42
D-1571.....	Manila Railroad Company.....	1,160	6	P. 65.....	Nov. 11, 1920	9,791.65
D-1578.....	Manila Hotel.....	515	8	P. 60.....	Aug. 20, 1920	7,431.69
D-1599.....	Anak Bayan Street, Paco.....	505	8	P. 35.....	Sept. 20, 1920	4,876.42
D-1612*.....	Juan Luna, Gagalangin.....	390	8	P. 50.....	Nov. 17, 1920	4,901.46
D-1616.....	Ayala & Company.....	560	6	P. 25.....	Nov. 24, 1920	4,196.83
D-1629.....	Santa Clara School.....	445	6; 4.5	P. 15.....	Dec. 29, 1920	3,692.68
D-1630.....	Del Pan Street, San Nicolas.....	300	6	P. 50.....	Dec. 19, 1920	2,601.02
D-1634*.....	Private, La Salle College.....	670	4.5	P. 38.....	Mar. 4, 1921	6,293.23
D-1658.....	Malate Market.....	650	6	P. 40.....	Mar. 21, 1921	5,627.15
D-1665.....	Manrique Street, Sampaloc.....	445	6	P. 12.....	Feb. 17, 1921	3,633.70
D-1674.....	Antonio Rivera Street, Tayuman.....	359	4.5	P. 30.....	Mar. 22, 1921	4,696.65
D-1676.....	Paco Market.....	330	6	P. 50.....	Mar. 22, 1921	2,763.26

D-1688 *	Maria Clara Street, Sampaloc	295	6; 8	P. 60	Apr. 26, 1921	3, 224.69
D-1689	O'Donnell Street	385	6	P. 60	Apr. 30, 1921	3, 328.09
D-1894 *	Herbosa Street, Tondo	460	6	P. 50	Feb. 26, 1923	4, 220.71
D-1921	G. Tuazon and Santiago Streets	525	6; 4.5	P. 45	June 28, 1923	4, 512.59
D-1929	Esguerra Street, Tondo	390	6	P. 30	Aug. 2, 1923	3, 306.26
D-1939	Muralla Street	730	4.5	P. 10	Nov. 9, 1923	6, 038.10
J-16079	Royal Ice Plant, San Miguel	795	6	P. 30	Oct. 7, 1924	5, 649.05
D-2111	Bureau of Prisons	650	6; 4.5	P. 30	June 9, 1925	5, 412.92
D-2293	Philippine General Hospital	837	8; 6; 4.5	P. 15	Oct. 12, 1926	6, 837.85
J-16768	Army and Navy Y. M. C. A., Intramuros	872	8; 10	P. 30	Jan. 6, 1927	9, 606.01
D-2425	Plaza de la Virgen, Pandacan	670	6	P. 25	Feb. 20, 1928	7, 122.94
D-2472	Bilibid Prison	800	6	P. 35	Nov. 7, 1928	-----
D-2613	Plaza Braulio, Tondo	493	6	P. 50	Jan. 28, 1930	-----

* No longer in use; closed or salty.

after some time have a few turned salty. It should also be remembered that salt water attacks iron pipes with ease and after a number of years leakage may occur. McCaw, however, claims that during the last five years he has found only one instance in which the casings have been corroded and have shown holes. This was the case of well No. 856, located on Dominga Street, Pasay, Rizal. The well was drilled during the latter part of 1915. It is 580 feet deep, has 460 feet of 6-inch casing and 567 feet of 4½-inch casing. About two years ago the well turned salty. The Bureau of Public Works pulled the 4½-inch casing during the latter part of 1930 and found the lower 300 feet coated with a crust one-third of an inch thick and badly corroded. Apparently, the casing is loose, as is shown by the formation of the crust outside of the pipe.

Salt water can be shut off entirely by cementation; that is, by cementing at the bottom of the well in such a manner that all the water passages are shut off.

The rôle that these artesian wells play in the routine life of the City of Manila is not fully realized, except when other supplies of potable water are cut off or dwindle to an alarming minimum. At such a time the artesian wells represent the main source of drinking water. From early morning, as early as 4 o'clock, and until late at night, water carriers can be seen at the different wells filling their 5-gallon cans, either for their own use or for sale in the neighborhood. At Plaza Miranda, Quiapo, at Blumentritt, San Lazaro, and at Magdalena Street, Trozo, the stream of water carriers is almost without break. In addition there are several private companies with wells of their own that are selling water at their plants or delivering it to their customers at their residences. Some employ their wells for private use entirely.

The value of these artesian wells to the City of Manila cannot be overestimated. During the rainy season of 1929 the main pipe of the Metropolitan Water District across Mariquina River broke and Manila was face to face with the possibility of having no water for domestic use. While workmen were frantically working to make the necessary repairs, and officials of the Metropolitan Water District in the City of Manila were calling upon the public to economize in the use of water, the population turned to artesian wells for their entire water supply and all the wells were pumped to their capacity. Lines of water carriers extended sometimes across a city block and not a few personal encounters were registered. Fortunately for the City of

Manila the water crisis lasted only a few days. What happened in 1929 may happen again. It is only necessary to call attention to the fact that Manila is in the earthquake belt and that a more-serious break in the water mains is possible. The artesian wells represent first aid of prime magnitude. In this connection the experience of Japan during the 1923 earthquake is here recalled. When the water mains of Yokohama broke and the city was without a water supply the one source of drinking water was a lone dug well in one of the sacred-temple grounds.³ The lesson is for a city as large as Manila to have several sources of good drinking water.

The one and most important use of underground water in Manila is for drinking purposes. The industrial uses made by ice plants and other establishments are small and represent but a very small fraction of the total consumption.

TABLE 2.—*Private artesian wells in the City of Manila.*

[Data furnished by Mr. Santiago Artiaga, city engineer of Manila.]

Name.	Location.	Depth in feet.	Pumping gallons capacity; per minute.
Watson & Co.	504 Aviles.	(*)	(*)
La Humildad.	Del Pan Street, San Nicolas.	(*)	(*)
Sternberg General Hospital.	Concepcion Street.	(*)	(*)
La Rosario.	1001 R. Hidalgo.	(*)	(*)
Adelante No. 1.	1338 Juan Luna.	(*)	(*)
Adelante No. 2.	do.	386	(*)
Magnolia.	660 Echague.	600	25
San Beda.	E. Mendiola Street.	(*)	(*)
La Yebana.	57 Gastambide.	479	15
Heacock.	Escolta, corner of David.	1,000	60
La Tondeña.	1068 Velasquez.	1,002	45 to 50
San Miguel Brewery.	132 Aviles.	693	15

* No record.

SUMMARY AND CONCLUSIONS

As a result of the present studies of the underground water supply of Manila the following conclusions are reached:

1. The underground water supply is sufficient to support at least ten times the number of artesian wells now existing, and more if necessary.

³ Personal communication from Dr. Otto Schöbl, Bureau of Science, Manila.

2. The fresh-water-bearing strata as a source of good drinking water are encountered at intervals from 100 meters down to 350 meters below the general level of the city, and probably at greater depths.

3. The records show that the wells that have been abandoned have been closed on account of the presence of salt water. Apparently the cause can be found either in loose casings or portions of the casings that are easily attacked by salt water and that in the course of time develop leaks through which salt water is pumped.

4. It is recommended that in the future all drillers after passing through salt-water-bearing strata pull their casing and properly put in cement at the bottom of the well in such a manner as to prevent salt water from again entering the well.

5. The danger of contaminated artesian wells is not in the water, which these wells bring up from the underground deeps, but in their use and construction and in the care given to them.

6. For the safety of the general public and to insure Manila a steady supply of good drinking water within reach of the poorest inhabitant, the water supply of the Metropolitan Water District should be supplemented with more artesian wells.

7. Future sites of artesian wells should be determined by a consideration of geology, number of wells in the vicinity, density of population, needs of the district, cost, and other factors.

LOGS OF WELLS

The logs of the different wells are here given based on the determinations made on the samples as submitted to the Bureau of Science. They are recorded here so that they can be checked by future drillers. The wells are arranged by districts, in alphabetical order. The depths are in feet as reported by the Bureau of Public Works. The location of these wells is indicated on Plate 1 of the following article, by Aguilar and Ocampo.

ERMITA

WELL No. 431.

Location: Bureau of Science, Herran and Taft Avenue.

Depth, 585 feet.

Cased.

Pumps 30 gallons per minute.

Feet.

0- 20. Greenish clay containing shells.

20- 45. Clay with fine basaltic pebbles, and a large amount of shell fragments.

45- 55. Calcareous material with limestone fragments.

Feet.

- 55-65. Same with more limestone, shell fragments, and grains of basaltic material.
 65-71. Fine brownish sand, some shell fragments, some pebbles.
 71-75. Coarser sand with shell fragments and coarse rock fragments.
 75-100. Light brown clay with shell and rock fragments.
 100-105. Stiff yellow clay.
 105-110. Sandy yellow clay with some red iron-stained fragments.
 110-116. Stiff reddish clay.
 116-120. Red shale.
 120-132. Stiff yellow clay with pebbles.
 132-147. Black clay with pellets of manganese oxide.
 147-155. Stiff brownish clay with fragments of limestone.
 155-165. Fine black gravel and yellow clay.
 165-180. Yellow sandy clay with some gravel.
 180-225. Sand and gravel.
 225-256. Fine yellow sand with some clay material.
 256-314. Coarse gray sand.
 314-336. Fine yellow sand with some pebbles.
 336-348. Coarse sand.
 348-350. Wood fragments.
 350-367. Black argillaceous mud.
 367-385. Coarse sand, black.
 385-405. Coarse sand, dark, with quartz, feldspar and olivine grains.
 405-435. Yellow sand.
 435-450. Gray sandy clay.
 450-472. Very light gray clay.
 472-500. Coarse yellow sand.
 500-525. Coarse sand, angular fragments, brownish black, rather clean.
 525-550. Light brown argillaceous gravel.
 550-565. Coarse brown sand like "336-348."
 565-585. Bluish stiff clay, roof of water.

WELL No. 1544.

Location: Manila Hotel, Port Area.

Depth, 427 feet.

Cased 368 feet.

Pumps 60 gallons per minute. Water stands 5 feet below the surface.

Determinations by L. A. Faustino.

Feet.

- 0-60. Gray clay with shells.
 60-136. Black clay with shells.
 136-187. Gray tuff with shells.
 187-250. Sandstone.
 220-250. Sand.
 250-310. Gray sandy tuff.
 310-320. Tuffaceous sand with coarse gravel.
 320-360. Yellow tuff.
 360-380. Gray sandstone.
 380-420. Tuffaceous sand.

WELL No. 1578.

Location: Manila Hotel, Port Area.

Depth, 515 feet.

Cased 374 feet.

Pumps 60 gallons per minute. Water stands 9 feet below the surface.

Determinations by L. A. Faustino.

Feet.

0-125. Gray clay with shells.

125-190. Gray sticky clay.

190-210. Pebbly clay with coarse gravel.

210-230. Coarse gravel.

230-250. Mixed igneous sand and gravel with shells.

250-267. Gray sandstone.

267-277. Tuff.

277-297v. Gray tuff with fine gravel.

297-320. Gray sandstone.

320-375. Yellow tuff.

WELL No. 2293.

Location: Philippine General Hospital, Manila.

Depth, 837 feet.

Cased 833 feet.

Pumps 15 gallons per minute. Water stands 90 feet below the surface
and 30 feet below when not pumping.

Determinations by L. F. Abad.

Feet.

0- 5. Yellow arenaceous clay.

6- 45. Gray tuffaceous clay with bits of shells.

46- 60. Yellow clay with bits of shells.

61- 80. Calcareous clay.

81-141. Black fossiliferous clay.

142-150. Fine and coarse sand.

155-167. Sand and gravel.

168-235. Tuffaceous sandstone.

236-250. Tuffaceous conglomerate.

251-272. Tuffaceous sandstone.

273-280. Medium coarse tuffaceous sand.

281-300. Coarse basaltic sand.

301-320. Tuffaceous sandstone.

331-340. Medium tuffaceous sand.

341-360. Tuffaceous clay.

361-419. Tuffaceous sandstone.

420-439. Coarse tuffaceous sand.

440-475. Tuff.

476-495. Tuffaceous clay.

496-505. Very fine quartzose sand.

506-522. Arenaceous clay.

523-586. Black clay with coarse basaltic sand.

586-675. Fine black sand.

676-726. Medium black sand.

Feet.

- 747-796. Dark brown arenaceous clay.
- 796-808. Black arenaceous clay.
- 809-813. Coarse basaltic sand.
- 814-830. Black arenaceous clay.
- 830-837. Black sand.

INTRAMUROS

WELL No. 1939.

Location: Muralla, near Victoria Street.

Determinations by A. D. Alvir.

Feet.

- 0- 40. Sandy and conglomeratic black clay with fragments of shells.
- 40-105. Yellow somewhat sandy clay with fragments of shells.
- 105-130. Bluish gray sandy clay with small shells.
- 130-160. Small dark moderately well-rounded gravel in a clayey matrix.
- 160-260. Yellowish gray sandy clay with tiny pebbles of dark material.
- 260-280. Bluish gray sandy clay with small shells.
- 280-310. Yellowish gray sandy clay.
- 310-350. Moderately well-rounded dark pebbles in a clayey matrix.
- 350-401. Light gray, very argillaceous, coarse sand with a few well-rounded pebbles.
- 401-408. Brownish to bluish gray, somewhat sandy, sticky clay with well-rounded pebbles.
- 408-470. Dark gray sandstone with a shiny black constituent, probably hornblende.
- 470-479. Yellowish gray clay with sand and fine gravel.
- 479-490. Light gray, probably tuffaceous, very argillaceous sand.
- 490-500. Gray sandstone.
- 500-515. Yellowish gray clay with small pebbles and shell fragments.
- 515-530. Dark gray moderately hard sandstone.
- 530-585. Medium dark gray sand.
- 585-595. Gray, probably tuffaceous, very argillaceous coarse sand.
- 595-597. Dark gray moderately hard sandstone.
- 597-625. Bluish gray sandy clay with shells.
- 625-630. Dark gray moderately hard sandstone.
- 630-633. Semisilicified wood.
- 633-665. Bluish gray sandy clay with shells.
- 665-687. Dark gray sand with tiny pebbles.
- 687-692. Tuff and fine light gray sand.
- 692-695. Dark gray moderately hard sandstone with some pieces of yellowish gray clay.
- 695-696. Fine sandy bluish gray clay with shells.
- 696-705. Dark gray moderately hard sandstone with some pieces of dark clay.
- 705-716. Fine dark gray sand.
- 716-730. Gravel, of basalt, well rounded in a matrix of dark sandstone.

WELL-JOB No. 16768.

Location: Aduana Street.

Depth, 872 feet.

Cased 172 feet.

Pumps 30 gallons per minute. Water stands 100 feet below the surface.

Determinations by L. F. Abad.

Feet.

- 0- 80. Black arenaceous clay.
- 80-120. Tuffaceous clay with shells.
- 120-130. Brown arenaceous clay.
- 130-137. Coarse basaltic sand with shells.
- 137-161. Basaltic gravel.
- 161-169. Gray tuffaceous clay.
- 169-182. Yellow tuffaceous clay.
- 182-215. Black clay with shells.
- 215-245. Black sandy clay.
- 245-255. Very fine sand.
- 255-292. Tuffaceous sand.
- 292-302. Fine sand.
- 302-346. Tuffaceous clay and sand.
- 346-371. Red clay with shells.
- 371-381. Basaltic sand.
- 381-391. Tuffaceous sand.
- 391-396. Basaltic sand and gravel.
- 396-410. Basaltic sand with pieces of wood.
- 410-422. Arenaceous clay.
- 422-432. Clay and coarse sand.
- 432-438. Medium sand.
- 438-446. Fine sandstone.
- 446-456. Yellow sandy clay.
- 456-471. Tuff.
- 471-495. Brown sandy clay.
- 495-509. Tuffaceous sand.
- 509-527. Sandy clay.
- 527-554. Basaltic sand.
- 554-557. Fine basaltic sand.
- 557-567. Tuffaceous clay.
- 567-571. Fine tuffaceous sand.
- 571-600. Very fine black sand.
- 600-628. Brown clay.
- 628-645. Black sandy clay.
- 645-655. Black sand.
- 655-672. Gray clay.
- 672-680. Tuffaceous and black sand.
- 680-687. Yellow sandy clay.
- 687-692. Fine tuffaceous sand.
- 692-700. Coarse tuffaceous sand.

Feet.

- 700-736. Medium black sand.
- 736-740. Sandy clay.
- 740-750. Very fine yellow sand.
- 750-760. Yellow sandy clay.
- 760-766. Gray sandstone.
- 766-782. Tuff.
- 782-806. Gray sandy clay.
- 806-823. Medium black sand.
- 823-869. Sandy clay.
- 869-872. Fine black sand.

MALATE

WELL No. 1658.

Location: Market site, Malate, Manila.

Depth, 650 feet.

Cased 569 feet.

Pumps 40 gallons per minute. Water stands 20 feet below the surface.

Feet.

- 0- 35. Gray tuffaceous clay with shells.
- 35- 72. Tuffaceous clay, sand, and gravel mostly basaltic.
- 72-110. Sandy clay with gravel and shells.
- 110-190. Marly clay with igneous and calcareous gravel.
- 190-230. Gray tuff.
- 230-280. Tuffaceous sand and gravel.
- 280-360. Fine gray tuff.
- 360-410. Tuffaceous sand.
- 410-445. Tuffaceous clay and gravel.
- 445-480. Tuffaceous sand.
- 480-515. Tuffaceous clay and gravel.
- 515-530. Fine gray tuff.
- 530-549. Tuffaceous clay and gravel.
- 549-571. Gray tuff.
- 571-610. Yellowish gravelly clay.
- 610-620. Fine tuffaceous sand.
- 620-650. Basalt gravel and sand.

WELL No. 2.

Location: Singalong Farm.

Feet.

- 0-408. No samples.
- 409-520. Fine gray volcanic ash.
- 520-535. Gray tuff.
- 535-570. Fine sand, dark pebbles, considerable quartz.
- 570-575. Medium sand, dark pebbles, considerable quartz.
- 575-595. Yellow tuff, rather clayey.
- 595-600. Gray tuff.
- 600-605. Fine pebbles, basaltic rock, some tuff.
- 605-607. Tuff and fine basaltic pebbles.

WELL No. 1634.

Location: La Salle College.

Depth, 970 feet.

Cased 586 feet.

Pumps 38 gallons per minute. Water stands 25 feet below the surface.

Feet.

- 1- 43. Yellow clay with shells.
- 43- 57. Gray clay with shells and calcareous gravel.
- 57- 77. Dark gray clay with shells.
- 77-120. Yellow sandy clay.
- 120-150. Tuffaceous sandy clay, light gray.
- 150-195. Dark gray clay with shells.
- 195-220. Tuffaceous sandy clay.
- 220-270. Tuffaceous clay.
- 270-275. Fine tuffaceous sand.
- 275-340. Tuff.
- 340-430. Gray tuff.
- 430-465. Fine tuffaceous sand.
- 465-498. Coarse tuffaceous sand.
- 498-534. Tuffaceous clayey sand.
- 534-560. Coarse tuffaceous sand.
- 560-590. Fragments of light vesicular lava.
- 590-635. Dark fine sand.
- 635-670. Very fine sand.

PACO

WELL No. 2425.

Location: Plaza de la Virgen.

Depth, 670 feet.

Cased 593 feet.

Pumps 25 gallons per minute. Water stands 64 feet below the surface when pumping, and 7 feet below when not pumping.

Determinations by L. F. Abad.

Feet.

- 0- 30. Tuffaceous clay.
- 30- 90. Yellow clay.
- 90-160. Medium sand.
- 160-200. Arenaceous clay.
- 200-225. Medium sand and coarse gravel.
- 225-350. Tuffaceous clay.
- 350-400. Medium basaltic sand.
- 400-415. Sand and gravel.
- 415-525. Gray arenaceous clay.
- 525-570. Tuff.
- 750-600. Tuffaceous sand.
- 600-670. Medium gray sand.

WELL No. 1675.

Location: Paco Market.

Depth, 330 feet.

Cased 324 feet.

Pumps 50 gallons per minute. Water stands 20 feet below the surface.

Feet.

- 0- 40. Dark gray clay with shell fragments.
- 40- 70. Yellowish clay with shell fragments.
- 70- 90. Tuffaceous sand.
- 90-110. Light gray clay.
- 110-160. Reddish sandy clay.
- 160-185. Light gray clay.
- 185-200. Basaltic sand and gravel.
- 200-230. Light gray clay, tuffaceous.
- 230-255. Tuffaceous sand.
- 255-278. Gray tuff.
- 278-300. Tuffaceous sand.
- 300-325. Light gray tuff.
- 325-328. Tuffaceous sand.
- 328-330. Basaltic sand and gravel.

WELL No. 1599.

Location: Anak Bayan.

Depth, 505 feet.

Cased 414 feet.

Pumps 25 gallons per minute. Water stands 25 feet below surface.

Determinations by L. A. Faustino.

Feet.

- 0- 30. Gray clay with shells.
- 30- 80. Yellow clay.
- 80-100. Gray sandstone.
- 100-150. Yellow clay.
- 150-220. Gray tuff.
- 220-260. Tuff.
- 260-300. Yellow tuff.
- 300-330. Tuff.
- 330-410. Gray tuff.
- 410-430. Tuff.
- 430-505. Tuffaceous sand.

PANDACAN**WELL No. 1433.**

Location: Jesus and Narciso Streets.

Depth, 470 feet.

Cased 461 feet.

Pumps 10 gallons per minute. Water stands at the surface.

Determinations by L. A. Faustino.

Feet.

- 0- 12. Black hard clay with shells.
- 12- 45. Tuffaceous and basaltic sand.
- 45-160. Tuff.
- 160-456. Tuffaceous and basaltic sand.
- 456-563. Black hard clay with shells.
- 463-470. Tuffaceous and basaltic sand.

QUIAPO

WELL No. 1446.

Location: Plaza Miranda.

Depth, 500 feet.

Cased 440 feet.

Pumps 10 gallons per minute. Water stands 7 feet below the surface.

Determinations by L. A. Faustino.

Feet.

- 0- 70. Greenish yellow clay with fine basaltic gravel.
- 70-120. Tuffaceous gray sand with shells.
- 120-140. Fragments of andesite, sandstone, and quartz.
- 140-230. Gray sandstone.
- 230-278. Black gravelly clay.
- 278-315. Gray sandstone.
- 315-340. Gray sandstone and black gravelly clay.
- 340-370. Black gravelly clay.
- 370-400. Black gravelly clay and tuffaceous sand.
- 400-440. Coarse tuffaceous sand.
- 440-455. Fragments of andesite, quartzite, and other rock.
- 455-490. Tuffaceous gray sand.
- 490-500. Gray sandstone.

WELL No. 2511.

Location: Philippine Cold Stores, near Quinta Market.

Determinations by L. F. Abad.

Feet.

- 0- 30. Yellow clay and sand.
- 30- 40. Fine basaltic sand.
- 40- 80. Gray tuffaceous clay with shells.
- 80- 90. Light brown arenaceous clay.
- 90-110. Coarse gravel.
- 110-140. Clay, sand, and gravel.
- 140-245. Tuff.
- 245-300. Fine basaltic sand.
- 300-307. Tuffaceous sand.
- 307-317. Coarse tuffaceous sand.
- 317-370. Tuffaceous sand.
- 370-382. Arenaceous clay.
- 382-465. Mixed basaltic sand and cuttings from tuff.
- 465-470. Mixed sand and cuttings from buried wood.
- 470-500. Tuffaceous sand.
- 500-560. Fine tuffaceous sand and gravel.

SAMPALOC

WELL No. 1688.

Location: Maria Clara Street.

Depth, 295 feet.

Cased 283 feet.

Pumps 60 gallons per minute. Water stands 1 foot below the surface.

Feet.

- 0- 32. Blue clay with shells.
- 32- 43. Brown gravelly clay with few shells.
- 43- 57. Basalt gravel.
- 57- 90. Gray tuff.
- 90-120. Dark gray tuffaceous clay.
- 120-190. Gray tuff.
- 190-270. Dark gray tuffaceous clay.
- 270-282. Gray plastic clay.
- 282-295. Basalt sand and gravel, scoriaceous.

WELL No. 1665.

Location: Manrique and Bustillos, Streets.

Depth, 445 feet.

Cased 225 feet.

Pumps 8 gallons per minute. Water stands at 8 feet below the surface.

Feet.

- 0- 37. Dark gray tuffaceous clay with shells.
- 37- 57. Brownish clay with shells.
- 57-215. Gray tuff.
- 215-220. Tuffaceous sand.
- 220-370. Gray tuff like "57-215."
- 370-425. Tuffaceous sand like "215-220."
- 425-445. Gray tuff like "57-215."

WELL No. 1505.

Location: Santa Mesa Market.

Depth, 555 feet.

Cased 495 feet.

Pumps 9 gallons per minute. Water stands 3 feet below the surface.

Determinations by L. A. Faustino.

Feet.

- 0- 17. Yellow clay.
- 18- 75. Tuffaceous and basaltic sand.
- 76-224. Gray tuff.
- 225-305. Tuffaceous and basaltic sand.
- 306-525. Gray sandy tuff.
- 526-555. Tuffaceous and basaltic sand (fine).

SAN MIGUEL

WELL No. 1616.

Location: Ayala and Co.

Depth, 560 feet.

Cased 460 feet.

Pumps 25 gallons per minute. Water stands at 40 feet below the surface.

Feet.

- 1-120. Dark gray clay with shells.
- 120-130. Tuffaceous sand.
- 130-250. Gray tuffaceous sand and clay.
- 255-285. Tuffaceous clay.
- 285-308. Gray tuffaceous sand and clay.

Feet.

- 308-325. Gray tuff.
- 325-420. Tuffaceous sand and clay.
- 420-470. Gray tuff.
- 470-495. Tuffaceous sand and clay.
- 495-525. Gray tuff.
- 525-560. Tuffaceous sand.

WELL-JOB No. 16079.

Location: San Miguel Brewery, General Solano Street.

Depth, 795 feet.

Cased 540 feet.

Pumps 30 gallons per minute. Water stands 200 feet below the surface.

Determinations by A. D. Alvir.

Feet.

- 0- 50. Gray tuffaceous clay.
- 50-120. Same with shells.
- 120-127. Sandy tuff with shells.
- 127-140. Gray sandy tuff.
- 140-155. Gray clayey tuff with many shells and wood fragments.
- 155-177. Gray sandy tuff.
- 177-190. Same but much coarser.
- 190-205. Sandy tuffaceous clay.
- 205-250. Clay with basaltic pebbles.
- 250-285. Hard dark clay.
- 285-356. Tuff.
- 356-380. Greenish gray clay with fine pebbles.
- 380-395. Sandy tuff.
- 395-435. Coarse tuffaceous sand.
- 435-460. Sandy tuff.
- 460-508. Greenish gray clay with fine pebbles.
- 508-525. Sandy tuff.
- 525-539. Hard tuffaceous dark clay.
- 539-552. Fine sand with hard shale.
- 552-579. Coarse tuffaceous sand.
- 579-613. Greenish gray sandy clay.
- 613-630. Gray sandy tuff.
- 630-689. Bluish gray clay.
- 689-695. Same but harder.
- 695-735. Fine dark sand.
- 735-774. Bluish gray clay with fine pebbles.
- 774-781. Dark sand with clay pellets.
- 781-795. Gray clay with sand and fine pebbles.

SAN NICOLAS**WELL No. 1630.**

Location: Del Pan Street.

Depth, 300 feet.

Cased 230 feet.

Pumps 50 gallons per minute. Water stands at 20 feet below the surface.

Feet.

- 0- 20. Tuffaceous sand and clay with shells.
- 20- 40. Gray gravelly clay.
- 40- 60. Light gray clay.
- 60- 72. Coarse, rounded, and much-decomposed sand.
- 72-100. Light gray clay.
- 100-140. Yellow sandy clay.
- 140-170. Basalt and andesite gravel.
- 170-192. Fragments from basalt with rounded gravel.
- 192-210. Marl.
- 210-260. Gray tuff.
- 260-300. Black basaltic sand.

SANTA ANA

WELL No. 1396.

Location: Near Public Market.

Depth, 543 feet.

Cased 539 feet.

Pumps 6 gallons per minute. Water stands 2 feet below surface.

Determinations by L. A. Faustino.

Feet.

- 0- 46. Broken shells.
- 75. Gray tuffaceous clay.
- 132. Basaltic and tuffaceous sand.
- 137. Yellow tuffaceous sand.
- 341. Basaltic scoria.
- 353. Tuffaceous yellow clay with fine gravel.
- 415. Gray tuff with shells.

SANTA CRUZ

WELL No. 1624.

Location: Santa Clara School, Andalucia and Cataluña Streets.

Depth, 445 feet.

Cased 320 feet.

Pumps 15 gallons per minute. Water stands at 6 inches below the surface.

Feet.

- 15. Brown sandy clay with shell fragments.
- 65. Basaltic sand and gravel.
- 77. Tuffaceous sandstone.
- 117. Gray tuff.
- 157. Basaltic sand and gravel like "65."
- 204. Rounded, coarse, and weathered basaltic sand and gravel.
- 316. Gray gravelly clay.
- 323. Gray tuff.
- 415. Coarse basaltic sand.

WELL No. 1689.

Location: O'Donnell Street.

Depth, 385 feet.

Cased 340 feet.

Pumps 60 gallons per minute. Water stands 3 feet below the surface.

Feet.

- 0-100. Gray tuffaceous clay.
- 100-115. Sand and gravel (basalt and andesite porphyry).
- 115-168. Gray tuff.
- 168-190. Tuffaceous sand and fine gravel with a few shell fragments.
- 190-305. Tuffaceous sand, fine grained.
- 305-337. Tuffaceous sand, coarse grained.
- 337-342. Tuffaceous gravel and sand, with shells (sample in collection).
- 342-355. Tuffaceous sand.
- 355-365. Cuttings from shale.
- 365-385. Mixed coarse basaltic sand and gravel, mostly scoriaceous and vesicular.

WELL No. 2111.

Location: Bilibid Prison.

Depth, 650 feet.

Cased 480 feet and 100 feet.

Pumps 30 gallons per minute. Water stands 22 feet below the surface.

Determinations by L. F. Abad.

Feet.

- 0- 30. Clay and sand.
- 30- 60. Fine gray sand with shells.
- 60- 90. Tuffaceous clay.
- 90-120. Basaltic sand.
- 120-150. Dark gray calcareous clay with shell fragments.
- 180-210. Tuffaceous sandstone.
- 210-270. Tuff.
- 270-330. Yellow clay with pebbles.
- 330-420. Tuffaceous clay.
- 420-510. Fine basaltic and tuffaceous sand.
- 510-540. Fragments of vesicular basalt.
- 540-570. Tuff with shell fragments.
- 570-600. Tuffaceous sandstone.
- 600-650. Fine sand with basaltic gravel.

WELL No. 2472.

Location: Bilibid Prison.

Depth, 800 feet.

Pumps 35 gallons per minute. Water stands 30 feet below the surface when pumping, and 20 feet below when not pumping.

Determinations by L. F. Abad.

Feet.

- 0- 30. Clay and sand. Salt water.
- 30- 40. Medium sand.
- 40- 50. Very fine tuffaceous sand. Fresh water.
- 50- 75. Dark gray fossiliferous clay. Dry.
- 75- 90. Basaltic gravel. Salt water.
- 90-105. Dark brown arenaceous clay.
- 105-155. Tuff.
- 155-195. Coarse gravel.

Feet.

- 195-220. Clay and igneous pebbles.
- 220-300. Basaltic gravel.
- 300-310. Tuffaceous clay.
- 310-315. Tuff with fine gravel.
- 315-425. Gray fossiliferous clay.
- 425-430. Tuffaceous clay. Fresh water.
- 430-470. Tuffaceous sandstone.
- 470-500. Fine sand and tuffaceous clay.
- 500-510. Basaltic gravel.
- 510-520. Fine sand and tuffaceous clay.

WELL No. 1528.

Location: San Lazaro Hospital.

Depth, 880 feet.

Cased 880 feet.

Pumps 50 gallons per minute. Water stands 40 feet below the surface.

Determinations by L. A. Faustino.

Feet.

- 0- 35. Yellow pebbly clay.
- 35-135. Red plastic clay.
- 135-295. Gray sandstone.
- 295-311. Gray sticky clay with shells.
- 312-338. Yellow pebbly clay.
- 339-343. Pumiceous sand and gravel.
- 344-870. Yellow tuffaceous sand.

WELL No. 1479.

Location: San Lazaro.

Depth, 422 feet.

Cased 412 feet.

Pumps 60 gallons per minute. Water stands 4 feet below surface.

Determinations by L. A. Faustino.

Feet.

- 0- 70. Coarse igneous gravel.
- 70-240. Yellow gravelly clay and tuff.
- 240-250. Tuff.
- 250-270. Tuffaceous and basaltic sand.
- 270-330. Tuff with basaltic gravel.

WELL No. 1456.

Location: Magdalena Street, Trozo.

Depth, 847 feet.

Cased 802 feet.

Flows $4\frac{1}{2}$ gallons per minute. Water rises 2 feet above the surface.

Determinations by L. A. Faustino.

Feet.

- 0- 15. Medium and fine sand.
- 16- 85. Gray tuff with shells.
- 86-100. Coarse igneous gravel.
- 110-126. Gray tuff with shells.

Feet.

- 126-242. Yellow tuff.
- 243-249. Gray sandstone.
- 250-325. Yellow gravelly clay.
- 326-372. Tuffaceous and basaltic sand.
- 373-393. Yellow gravelly clay.
- 394-445. Gray sandy tuff.
- 506-600. Gray gravelly clay.
- 601-606. Yellow sandy clay.
- 606-635. Basaltic gravel.
- 636-670. Gray plastic clay.
- 671-695. Yellow clay.
- 696-765. Light gray clay.
- 712-847. Yellow tuffaceous sand.

TONDO

WELL No. 1612.

Location: Gagalangin, Manila.

Depth, 390 feet.

Cased 341 feet.

Pumps 50 gallons per minute. Water stands 7 feet below the surface.

Feet.

- 0- 21. Gray clay with shells.
- 21- 45. Gravelly clay with fragments of shale.
- 45- 70. Black carbonaceous clay.
- 70- 90. Gray gravelly clay.
- 90-110. Basalt gravel.
- 110-140. Gray tuff.
- 140-318. Tuffaceous clay.
- 318-390. Tuffaceous sandstone.

WELL No. 1571.

Location: Manila Railroad Station.

Depth, 1,160 feet.

Cased 1,065 feet.

Pumps 65 gallons per minute. Water stands at 55 feet below the surface.

Feet.

- 0- 25. Gray pebbly clay.
- 26- 54. Brown sandy clay.
- 55- 95. Light gray tuffaceous clay.
- 96- 118. Sand and gravel, basalt abundant, some andesite and massive quartz.
- 119- 150. Black fine-grained sand, considerable magnetite grains.
- 151- 327. Sand and gravel, tuffaceous.
- 328- 352. Sharp-grained tuffaceous sand.
- 353- 445. Brown sandy clay, tuffaceous.
- 446- 460. Dark gray clay.
- 461- 575. Fine tuffaceous sand, magnetite quite abundant.
- 576- 580. Blue gravelly clay.

Feet.

- 581- 615. Fine tuffaceous sand.
- 616- 640. Gray tuffaceous clay and sand.
- 641- 655. Very fine sand.
- 656- 787. Gray tuff.
- 788- 807. Fine tuffaceous sand.
- 808- 954. Dark brown clay.
- 955-1080. Gray tuffaceous clay.
- 1081-1123. Very fine sand.

WELL No. 1674.

Location: Antonio Rivera Street.

Depth, 360 feet.

Cased 308 feet.

Pumps 30 gallons per minute. Water stands 14 feet below the surface.

Feet.

- 0- 30. Blue sandy clay with shells.
- 30- 85. Brown clay with gravel.
- 85-100. Fine gravel, mostly basaltic. Salt water.
- 100-130. Yellow sandy clay.
- 130-146. Tuffaceous sandstone. (Salt water.)
- 146-150. Coarse tuffaceous sand. (Salt water.)
- 150-195. Tuffaceous sandstone like "130-146."
- 195-210. Tuffaceous sand and gravel.
- 210-237. Tuffaceous sandstone like "130-146."
- 237-244. Tuffaceous sand.
- 244-250. Gray clay.
- 250-305. Tuffaceous sandstone like "130-146."
- 305-359. Coarse tuffaceous sand. Fresh water.

WELL No. 1929.

Location: Esguerra Street.

Depth, 390 feet.

Cased 321 feet with 6-inch pipe.

Pumps 30 gallons per minute. Water stands 16 feet below the surface.

Determinations by R. F. Abarquez.

Feet.

- 0- 20. Greenish somewhat consolidated silt with shells.
- 20- 38. Dense basaltic subangular fragments.
- 38- 95. Yellowish sandy and gravelly clay.
- 95-145. Gray silt with shell fragments.
- 145-190. Sand and gravel, mostly of dense basalt.
- 190-240. Yellowish gray volcanic sand, somewhat consolidated.
- 240-295. Gray clay loam with tiny shells.
- 295-337. Yellowish gray volcanic sand, somewhat consolidated.
- 337-385. Gray volcanic sand.
- 385-390. Black volcanic, mostly coarse, sand.

WELL No. 1894.

Location: Herbosa Street.

Depth, 460 feet.

Cased 400 feet with 6-inch pipe.

Pumps 50 gallons per minute. Water stands at 24 feet below the surface.

Determinations by R. F. Abarquez.

Feet.

0- 20. Black clay loam.

20- 95. Yellow sandy and pebbly clay.

95-110. Black clay loam with few shell fragments.

110-136. Gray pumiceous sand.

136-159. Coarse gravel.

159-233. Tuff.

233-251. Volcanic sand.

251-274. Yellow gravelly clay.

274-396. Tuff.

396-460. Black volcanic sand.

WELL-JOB No. 14878.

Location: Moriones Street.

Depth, 851 feet.

Cased 625 feet.

Pumps 20 gallons per minute. Flows 5 gallons per minute. Water rises 2 feet above the surface.

Determinations by L. A. Faustino.

Feet.

0-740. No samples.

740-760. Tuffaceous sand.

760-780. Gray tuff.

780-800. Tuffaceous sand.

820-840. Tuff.

840-851. Tuffaceous sand.

ILLUSTRATIONS

PLATE 1

Artesian well in Pandacan, near the corner of Jesus and Narciso Streets.
(Photograph by the Bureau of Public Works.)

PLATE 2

Artesian well near San Lazaro market. (Photograph by the Bureau of Public Works.)

PLATE 3

Artesian well at Plaza Miranda, Quiapo. (Photograph by the Bureau of Public Works.)

TEXT FIGURES

- FIG. 1. Manila and neighboring towns. (Based on Coast and Geodetic Survey map. Drawn in the division of mines, Bureau of Science.)
2. Sections of wells in Manila. (Drawn in the division of mines, Bureau of Science.)
 3. Geologic section east and west across Manila and vicinity, diagrammatic; showing artesian conditions; *a*, alluvium; *b*, tuff; *c*, impervious material. (Drawn in the division of mines, Bureau of Science.)

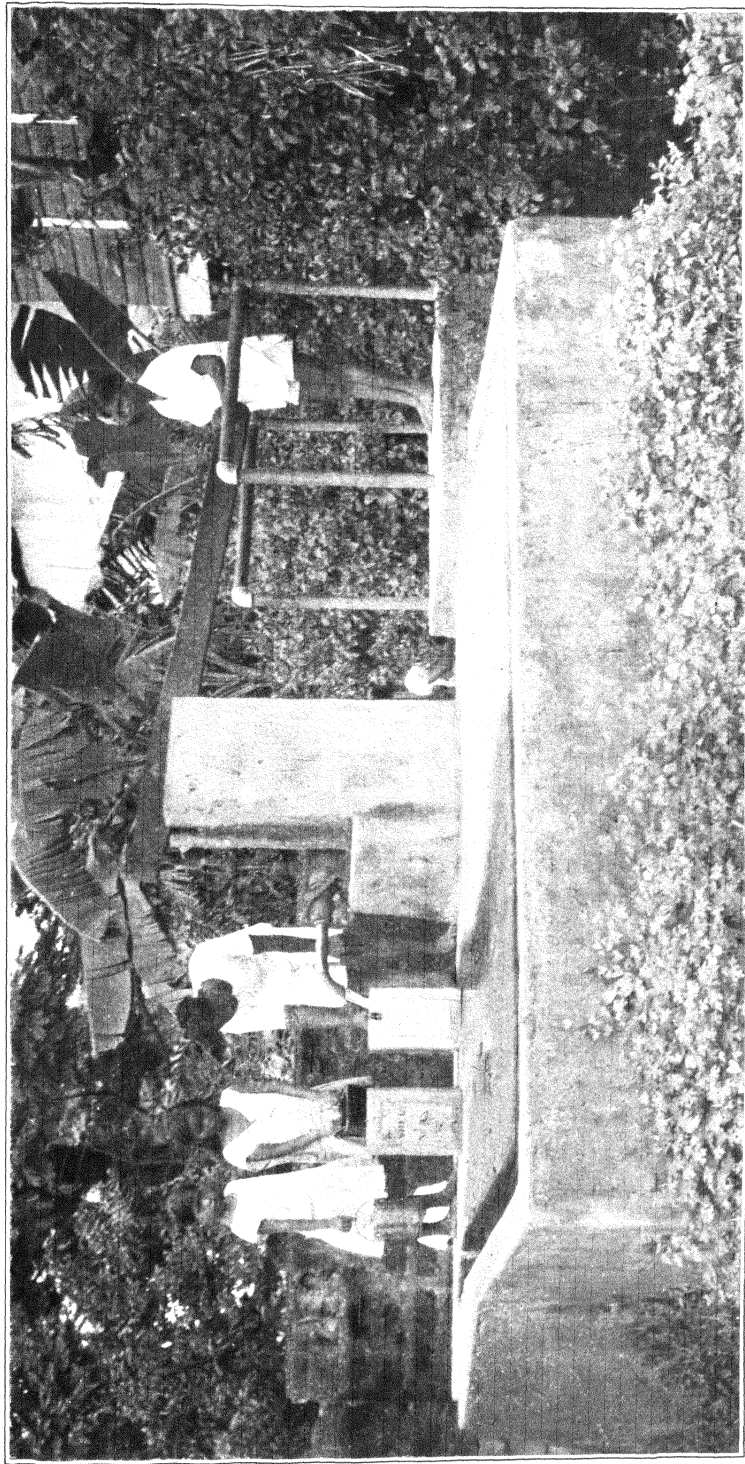


PLATE 1. ARTESIAN WELL IN PANDACAN.

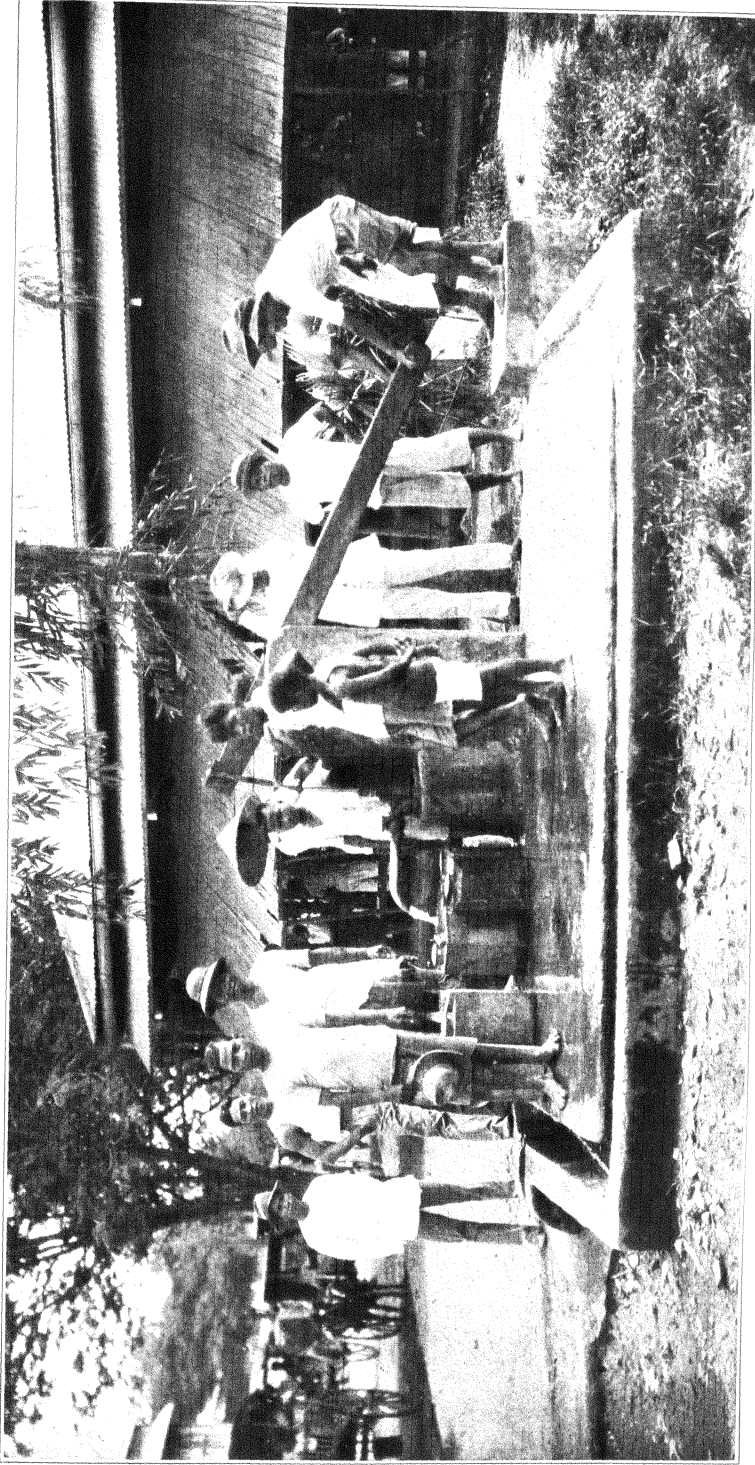


PLATE 2. ARTESIAN WELL NEAR SAN LAZARO MARKET.

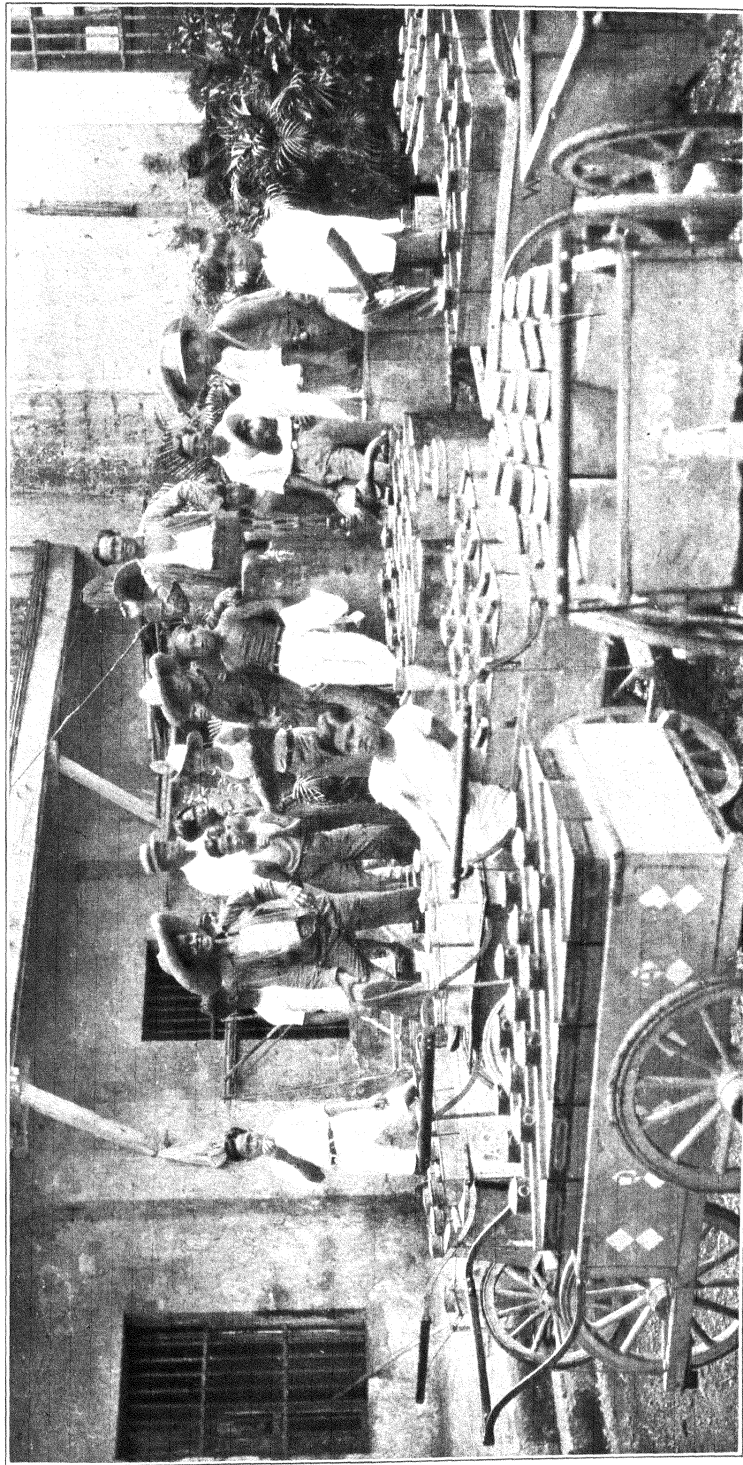


PLATE 3. ARTESIAN WELL AT PLAZA MIRANDA, QUIAPO.

ARTESIAN-WELL WATERS IN MANILA AND NEIGHBORING MUNICIPALITIES

By R. H. AGUILAR and LOURDES OCAMPO
Of the Bureau of Science, Manila

ONE PLATE

A great number of the inhabitants of the City of Manila and the majority of those in the neighboring municipalities obtain their drinking water from artesian wells. These are conveniently distributed so as to be accessible to the greatest number of people.

In previous years the first artesian waters were looked upon with suspicion¹ because the people were accustomed to drinking surface waters; but now, surface waters are almost completely abandoned for artesian waters, and even in the City of Manila where the city water is constantly under chemical and bacteriological control² a great proportion of the people prefer to use artesian waters for drinking purposes.

The first two artesian wells drilled for the Insular Government in Manila³ were those located on Engineer Island and at Singalong Agricultural Experimental Station. The first was drilled by the Bureau of Coast Guard and Transportation and the second by the Bureau of Engineering. The work was performed in 1904. In the succeeding years more wells were drilled in the provinces. The satisfactory results observed by the people from the use of artesian waters, especially from the hygienic point of view,⁴ caused many municipal councils to pass resolutions requesting the drilling of wells in their municipal-

¹ Heise, G. W., and A. S. Behrman, *Philippine Water Supplies*, Manila, Bu. Sci. Mon. 11 (1918) 11.

² Heise, G. W., *Philip. Journ. Sci.* § A 11 (1916) 1; and Taylor, Edward, *Philip. Journ. Sci.* 27 (1925) 297.

³ Report U. S. Bur. of Eng. fiscal year ending June 30, 1905. Washington (1906) 174.

⁴ Cox, A. J., G. W. Heise, and V. Q. Gana, *Philip. Journ. Sci.* § A 9 (1914) 275.

⁵ Bur. of Pub. Works Annual Reports fiscal year ending June 30, 1907-1908, 1909, and 1910, Manila (1908) 33 and (1910) 28.

ities.⁵ For similar reasons the municipal council of the City of Manila voted funds for the installation of artesian wells at convenient places in the city. The Bureau of Public Works completed the drilling of the first wells in 1919.⁶ In the following years, more wells were drilled, and at present there are several artesian wells in every district within the city limits.

In view of the many requests for information, frequently received at the Bureau of Science regarding the properties of the waters from these wells and those in the neighboring municipalities, this work was undertaken for the purpose of gathering up-to-date data on which to base opinions on the quality of the waters, from the hygienic standpoint, and on their relative general characteristics and therapeutic values.

SCOPE OF THE WORK

A large proportion of the public artesian wells now in operation within the city limits and those in the nearby municipalities were included in this study. The work as outlined comprises the collection of samples and the chemical analysis of the samples. The temperature of the air and that of the water, the popularity of the well, judged from the number of persons using it, and the rate of flow were also noted. The average temperature of the waters is slightly higher than the temperature of the air.

GENERAL PLAN AND METHODS OF WORK

Eighty-two of the eighty-four wells examined are pumping wells, and two are flowing wells. The water was kept flowing for at least twenty minutes, measuring at the same time the rate of flow by means of a calibrated container, before samples were collected. For this purpose 4-liter bottles were used, filling them completely to the stopper. As soon as the specimens arrived at the laboratory, almost always within forty-five minutes after collection, the acidity, alkalinity, and nitrate determinations were made. The standard methods for the examination of water and sewage by the American Public Health Association⁷ were strictly followed in the chemical examination of the water samples.

⁵ Bur. of Pub. Works, Quarterly Bull. 28 (1920) 6.

⁷ Standard Methods of Water Analysis, Am. Pub. Health Ass., New York (1925).

ANALYTICAL DATA

In the tabulation of analytical data, both the ionic form and the combined form of stating results were adopted. The statement in ionic form enables the reader to compare the mineral composition of these waters with the mineral composition of those in the United States, because the same form of statement is employed by the United States Geological Survey⁸ in reporting mineral analyses of waters. On the other hand, the greater proportion of the local medical practitioners and health officers, who are the ones usually consulted in regard to the mineral quality of the waters and their suitability for drinking uses, are more familiar with the combined form than with the ionic form.

There is a great variety of methods of reporting results of analyses in the combined form. Dole⁹ mentions several references to directions given by various authors.¹⁰ A recent publication by Thresh and Beale¹¹ gives a method which, according to them, in practice works out more in accordance with the order of probability, and is based upon a list of salts that may enter into solution in natural waters in the order of their insolubility as given by Bunsen in his "Instruction für die Ausführung der vom Grossherzogl. Bad. Ministerium des Innern angeordneten chemischen Untersuchung der Badischen Mineral Wasser."

Of the various methods of combining the basic and acid ions, the one followed by Haywood and Smith¹² in reporting the analyses of the mineral waters in the United States was adopted for convenience. According to this method, the order of cal-

⁸ U. S. Geological Survey, Water-Supply Papers.

⁹ U. S. Geol. Surv. Water-Supply Paper 236 (1909) 40.

¹⁰ (a) Walter, G., und A. Gärtner, Tiemann-Gärtner's Handbuch der Untersuchung und Beurtheilung der Wässer, Braunschweig (1895) 357. (b) Wankling, J. A. and E. T. Chapman, Water-Analysis, 10th ed. Kegan Paul, Trench, Trübner and Co. Ltd., London (1896) 149. (c) Stillman, T. B., Engineering Chemistry, 3d ed. Chem. Pub. Co., Gaston, Pa. (1905) 47. (d) Fresenius, C. R., Quantitative Chemical Analysis, edited by O. P. Allen and S. W. Johnson. John Wiley and Sons, New York (1900) 674.

¹¹ The Examination of Waters and Water Supplies, 3d. ed. J. and A. Churchill, London (1925) 349.

¹² U. S. Dept. Agr. Bur. Chem. Bull. 91 (1905) 17.

culating the "hypothetical" combinations of the basic and acid ions is as follows:

Sodium is joined to nitrous and nitric acid, potassium to iodine and bromine, calcium to phosphoric acid, and sodium to metaboric acid. The residual basic ions are then assigned in the following order—ammonium, lithium, potassium, sodium, magnesium, calcium, manganese, iron and aluminium—to the residual acid ions in the following order—chlorine, sulphuric acid ion, carbonic acid ion and bicarbonic acid ion. In case the bicarbonic acid ion is not present in sufficient quantities to join with all the calcium, the residual calcium is joined to silica to form calcium silicate, and manganese, iron, and aluminium are calculated to the oxides Mn_2O_4 , Fe_2O_3 , and Al_2O_3 , respectively.

After reading the various references on this subject, one is led to the conclusion that the statement of results in combinations has to be necessarily of a hypothetical nature. It is for this reason, no doubt, that different chemists combine the ions following arbitrary rules and methods which at the time may appear reasonable or advisable, and the result, as Clarke¹³ has so aptly stated, "is a meaningless chaos of assumptions and uncertainties." It is apparent, therefore, that there must not be attached much significance to the hypothetical combinations adopted. They are here given to enable those that are accustomed to this form of report to interpret the qualities of the waters from the chemical results. After all, whether the analysis is given in ionic form or combined form, the substances present in predominating quantities will be in evidence and will determine the chemical character of the water.

BASIC CONSIDERATIONS IN DETERMINING THE QUALITY OF A WATER

Statements given in this work regarding the chemical qualities of waters used for drinking purposes are based upon the mineral constituents. No reference is given to the sanitary character of the waters from the chemical standpoint, because the usual analyses for free and albuminoid ammonia, nitrites and oxygen consumed, to determine pollution by disease-producing bacteria have been purposely left out, as unnecessary, under present conditions.

In this connection, Stephenson, Logan, and Waring¹⁴ point out that in the case of deep wells, "the possibility of pollution

¹³ Bull. U. S. Geol. Surv. 330 (1908) 54.

¹⁴ U. S. Geol. Surv. Water-Supply Paper 576 (1928) 23.

can best be determined by inspection of the surroundings. Surface waters, shallow wells, and many springs require special care to prevent contamination. Deep wells are in general safer and are very rarely contaminated except by surface waters that may enter through defective casings." Contamination of this nature is detected by bacteriological examination supplemented with tests to determine any change in the mineral constituents. Thresh and Beale¹⁵ are also of the opinion that the common practice of judging the purity of waters for human consumption on the basis of their content of nitrogen and oxygen consumed is not reliable. The following quotation is from Thresh and Beale:

It must also be remembered that the term [pure water or wholesome water] originated before bacteria were thought of in connection with water, and when impurities were chiefly connected with water yielding excessive quantities of free or albuminoid ammonia, or of organic carbon or nitrogen. * * * Since the discovery of bacteria and the general recognition of the fact that they are the chief causes of unwholesomeness in water, our increasing knowledge of the constituents of water leads us to lay less and less stress upon the ammonias, carbon and nitrogen, as the bodies yielding these may be quite as harmless as chlorides or nitrates; consequently we find Sir A. Houston¹⁶ defining a pure and wholesome water in a way which ignores this organic matter altogether.

Heise and Behrman,¹⁷ in their work on Philippine water supplies, have already discussed the status of nitrogen determination in waters. After citing the experiences of Barnard¹⁸ who, working on river waters, found out that free and albuminoid ammonia generally depend more on low and high water, temperature, and normal vegetable growth than upon pollution, they themselves made the following concluding remarks:

Since the nitrogen content of deep wells is almost sure to be misleading, since simple determinations are of doubtful value, and since the nitrogen in its various forms can be determined accurately only on fresh samples of water, the nitrates, nitrites, and free and albuminoid ammonia determination may be omitted for all but exceptional cases.

In the tables, however, the test for nitrates was included to make this work comparable with similar works published by the United States Geological Survey.

¹⁵ *The Examination of Waters and Water Supplies*, 3d ed. J. and A. Churchill, London (1925) 142.

¹⁶ *Lancet* 1 (January 27, 1923).

¹⁷ *Philippine Water Supplies*, Bu. Sci. Mon. 11 (1918) 107.

¹⁸ *Engineering Record* (1913) 68, 297.

RELATION OF THE MINERAL CONSTITUENTS TO THE QUALITY
OF THE WATERS

Perhaps one of the most difficult problems of a water chemist is to establish chemical standards on which to base opinions on the quality of drinking waters. Chemically pure water, in the words of Sir A. Houston,¹⁹ is one that does not contain saline constituents that are objectionable either in quality or in quantity, and contains only the merest traces of organic matter. Heise and Behrman²⁰ believe that the best water for human consumption is water that is as free as possible from organic matter and that contains only relatively small quantities of the normal mineral ingredients of natural waters. Ellis and Lee²¹ seem to hold the same belief. They state that the lower waters are in mineral content the more acceptable they are as sources of supply.

The agreement on this point is apparent; that is, the least-mineralized waters are the best waters for human consumption. In regard to the maximum values for mineral tolerance, however, opinions are as variable as individual taste and idiosyncrasy. According to Cox, Heise, and Gana,²² a water containing 1,000 parts per million mineral matter is liable to prove laxative. A water containing 1,000 parts per million or more of total dissolved solids is classified by L. Grünhut²³ as mineral water, to distinguish it from the ordinary spring or well water. Buswell²⁴ is of the opinion that above 500 parts per million of mineral matter, the water has a salty or brackish taste detectible by most people. He observes, however, that he has known a public supply containing 2,000 parts per million of total solids. MacDougal²⁵ reports that the experience of the field expeditions from the desert laboratory of the Carnegie Institution demonstrates that saline or alkaline water containing as much as 2,500 milligrams per kilogram (2,500 parts per million) of dissolved salts may be used for periods of many days

¹⁹ *Lancet* 1 (January 27, 1923) 193.

²⁰ *Philippine Water Supplies*, Bu. Sci. Mon. 11 (1918) 19.

²¹ U. S. Geol. Surv. Water-Supply Paper 446 (1919) 226.

²² *Philip. Journ. Sci.* § A 9 (1914) 381.

²³ *Zeitschr. f. Balneol.* (1912) 4, 433-6, *Wasser u. Abwasser* (1912) 5, 417-20, *Pharm. Zentralh.* (1914) 55, 180.

²⁴ *The Chemistry of Water and Sewage Treatment*. The Chem. Cat. Co., N. Y. (1928) 71.

²⁵ *Botanical Features of North American Deserts*, Carnegie Institution Pub. 99 (1908) 109.

without serious discomfort, but if the proportion be increased to about 3,300 milligrams (3,300 parts per million) only hardened travellers may use the supply. Ellis and Lee²⁶ give the following ratings of waters by total solids. Low-mineralized waters, those containing 150 parts per million or less of total solids; moderately mineralized, between 150 and 500; highly mineralized, between 500 and 2,000; very highly mineralized, over 2,000.

Water supplies containing salt, as sodium chloride, from 500 to 700 parts per million (303 to 425 parts per million as chlorine) are not objectionable.²⁷ However, very much smaller quantities of calcium or magnesium chlorides would give the water a disagreeable taste. The American Water Works Association²⁸ gives as the limiting value for chlorides 250 parts per million (as chlorine).

In general, the sulphate (SO_4) content of deep-well waters in the Philippines is usually low. In this work only two specimens were found to contain above 200 parts per million sulphates (as SO_4). Magnesium and sodium in combination with the sulphate radical (SO_4) are cathartic. Seven hundred fifty milligrams magnesium per kilogram (750 parts per million) should be considered the maximum.²⁹ A water containing 42 grains crystallized magnesium sulphate ($\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$) and 42 grains British Pharmacopœia sodium sulphate ($\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$) per imperial gallon (equivalent to 234 and 179 parts per million SO_4 , respectively) was pronounced unsuitable for domestic purposes³⁰ considering the amount that might be imbibed daily under tropical conditions and the prevalence of choleric diseases in the locality.

As to carbonates (as sodium carbonate) the amount present may vary from 20 or 30 parts to 500 parts of carbonate per million, the latter approaching in character some of the greatly vaunted "table" waters. In this connection, it is interesting to note that the greater proportion of the deep-well waters examined are soft alkaline waters, characterized by the predomi-

²⁶ U. S. Geol. Surv. Water-Supply Paper 446: 228.

²⁷ Thresh and Beale, *The Examination of Waters and Water Supplies*, 3d ed. J. and A. Churchill, London (1925) 206.

²⁸ Public Health Reports, No. 15, 40 (1925) 718.

²⁹ Dole, R. B., U. S. Geol. Surv. Mineral Resources of the U. S., Washington (1912) 1185-6.

³⁰ Thresh and Beale, *The Examination of Waters and Water Supplies*, 3d ed. J. and A. Churchill, London (1925) 148.

nance of sodium carbonates or bicarbonates. The following quotation from Thresh's report when he was medical officer of health for the County of Essex, England, will furnish some idea on the quality of sodium-carbonated or sodium-bicarbonated waters.³¹

During the twenty years I have had these districts under observation there has never been the slightest reason to suspect that any of the above public water supplies were of anything but the most wholesome character. In many parts of the country we have small local supplies containing much more of the soda salts, and they are equally wholesome. The most popular table waters in the world are waters which contain larger quantities of the above soda salts, and a large proportion of the members of the medical profession regard them as more suitable for drinking purposes than ordinary hard waters.

Natural seltzer water contains about 58 grains of carbonate of soda per [imp.] gallon [820 parts per million].

Natural Apollinaris water contains about the same quantity.

A natural water bottled at Peterborough contains about 40 grains [570 parts per million] of carbonate and $12\frac{1}{4}$ grains [175 parts per million] of sulphate of soda and is very highly spoken of by the "Lancet" (Feb. 1904) in whose laboratory the analysis was made.

In regard to the degree of hardness of waters, the English Parliament in a bill ³² decided that a water of about 22° (Clark) hardness (315 parts per million) should be softened; which is in accord with the belief of Permain and Moor ³³ that a greater hardness than 300 parts per million is undesirable from the hygienic standpoint. Middleton's ³⁴ limiting value is 350 parts per million. Chase, ³⁵ studying the relation of hardness in water supply to public health, reached the conclusion that statistical evidence indicates no relation between hardness in drinking waters and death from disease of the arteries, kidneys, and bladder. The hardness of the waters studied ranges from 10 to 30 parts per million for soft waters, from 100 to 250 parts per million for hard waters. Meyers, ³⁶ in his efforts to find the effect of hard water on growth, appearance, and general well being, performed a series of experiments on white mice, white rats, young rabbits, dogs, calves, and several groups of chicks. His findings were that animals develop better with the use of hard wa-

³¹ Thresh and Beale, op. cit. 150.

³² Thresh and Beale, op. cit. 152.

³³ Mason, W. P., *Examination of Water*. John Wiley and Sons, Inc., New York (1917) 34 and 35.

³⁴ Loc. cit.

³⁵ Journ. Am. Water Works Ass. 2 (1924) 873.

³⁶ Journ. Infec. Dis. 37 (1925) 13-34.

ter than with distilled water under several conditions. He used a very hard natural water, having a total hardness of 520 parts per million CaCO_3 .

The following data taken from different publications will furnish an idea of the more or less arbitrary way waters are classified according to the degree of hardness.

Classification by Thresh and Beale.⁸⁷

- Less than 50, very soft.
- 50 to 100, fairly soft.
- 100 to 150, neither hard nor soft.
- 150 to 200, moderately hard.
- 200 to 300, hard.
- 300 and over, very hard.

Classification by Permain and Moore.⁸⁸

- 30 to 50, very soft.
- 50 to 100, moderate.
- 100 to 300, hard.
- 300 and over, very hard.

Classification by Buswell.⁸⁹

- Less than 100, soft.
- 100 to 200, moderately hard.
- 200 to 500, hard.
- 500 and over, saline.

Baskerville.⁹⁰ Less than 50 parts per million, soft, above 100, hard; between 50 and 100, open to discussion and dependent upon local preferences.

CLASSIFICATION OF WATERS ON THE BASIS OF THE PREDOMINATING MINERAL CONSTITUENTS

In classifying the waters on the basis of their mineral constituents, the method adopted by Peale,⁴¹ as modified by Haywood and Smith,⁴² has been followed as the best adapted to our purpose. It was pointed out by Bartow, however, that these classifications and others of a similar nature are of limited value, since they refer to the kinds with no reference to the amounts of constituents, as Buswell⁴³ clearly illustrates in the following

⁸⁷ Waters and Water Supplies, J. and A. Churchill, London (1925) 214.

⁸⁸ Mason's Examination of Water 35.

⁸⁹ The Chemistry of Water and Sewage Treatment. The Chem. Cat. Co. Inc., New York (1928) 71.

⁹⁰ Municipal Chemistry. McGraw-Hill Book Co., New York (1911) 88.

⁴¹ A System of Physiologic Therapeutics, edited by S. S. Cohen 9: 302.

⁴² U. S. Bu. Chem. Bull. 91 (1905) 9.

⁴³ The Chemistry of Water and Sewage Treatment. The Chem. Cat. Co., N. Y. (1928) 71.

TABLE 1.—*Mineral analyses of waters from artesian wells located in Manila and neighboring municipalities.*

[Report of analysis in ionic form. Results in milligrams per liter.]

Tracing No.	Location.	Well No.	Depth of well; meters.	Date of collection of samples.	Capacity; liters per minute.	Total solids (at 180° C.).	Silica (SiO ₂).	Iron (Fe).	Aluminum (Al).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).
1	2	3	4	5	6	7	8	9	10	11	12	13
MANILA.												
M-1	Santiago, near G. Tuason, Sampaloc.	1921	160	July 23	29	215	28	0.03	0.62	1.7	tr	59
2	Plaza Guipit, Sampaloc.			Sept. 11	31	250	30	0.11	0.77	2.6	tr	76.5
3	Plaza Moriones, Tondo.		260	May 29	30	260	24	0.06	0.8	2	tr	84
4	Corner Victoria and Muralla Streets, Intramuros.	1939	223	May 20	30	275	26	0.44	1.6	2.9	tr	85
5	San Lazaro Hospital.	1528	269	July 13		295	30	0.13	0.75	0.86	tr	95
6	Esguerra, between Yangco and Franco Streets, Tondo.	1929	119	July 22	35	305	34	0.07	0.8	1.7	tr	95
7	Santa Mesa Market, at Teresa Street.	1505	170	July 11	24	315	40	0.06	0.8	3.4	tr	97
8	Estado Street, between Benavides and Magdalen.	1456		June 8	8	350	54	0.16	0.94	1.1	tr	115
9	San Lazaro Market, Blumentritt Street.	1479	129	June 27	33	350	65	0.07	1	3.4	tr	112
10	Santa Clara School, Andalucia Street.	1629	136	July 18	27	370	74	0.11	0.76	1.4	tr	105
11	Antonio Rivera, near Tayuman.	1674	122	July 20	34	370	70	0.07	0.58	1.7	tr	102
12	Manrique Street, in front of Sampaloc Church.	1665	136	June 13	26	375	50	0.06	0.81	3.4	tr	123
13	Jesus and Narciso Streets, Pandacan.	1433	144	June 25	34	395	64	0.06	1	3.4	tr	116
14	Plaza Miranda, at Quiapo Church.	1436	153	June 4	34	485	60	0.12	1.2	3.7	tr	144
15	O'Donnell, between Lope de Vega and Zurbaran.	1689	118	July 6	29	545	61	0.05	1	10	tr	175
16	Anak Bayan, Paco.	1599	154	July 9	33	545	69	0.14	1.2	4	tr	185
17	Del Pan, San Nicolas.	1630	92	July 19	45	595	83	0.16	0.72	8.3	2.7	175
18	Paco Market, Dart and Herran Streets.	1675	101	June 21	36	625	77	0.14	1.2	8.6	4	198
19	Santa Ana Market, Calderon Street.	1396	166	June 11	28	755	57	0.11	0.98	10	tr	243

20	Engineer Island.....	1	178	Oct. 8	---	380	66	0.06	0.8	16	tr	279.6
21	Plaza de la Virgen, Pandacan.....	2425	205	Aug. 12	30	965	55	0.42	0.95	19	tr	292
22	Malate Market, Leveriza Street.....	1658	198	May 17	34	1,145	68	0.12	1.2	18	tr	309
CALOOCAN.												
C-1	Novaliches Road, between kms 10 and 11.....	---	---	Sept. 19	30	180	23	0.06	0.81	5.4	tr	55.5
2	Balon Bato, Novaliches Road, between kms 9 and 10.	2487	150	Sept. 24	32	180	26	0.05	0.81	2.8	tr	59
3	Cangcong Barrio, Novaliches Road, between kms 8 and 9.	2576	107	Sept. 27	63	215	37	0.12	0.97	3.7	2.1	62.5
4	Rizal Avenue extension, between kms 6 and 7.	1916	151	July 3	30	220	20	0.02	0.41	5.2	tr	75
5	Balintawak, near km 9.....	895	126	Oct. 1	39	225	32	0.16	0.94	4	tr	69.3
6	Novaliches Road, between kms 17 and 18.	2505	107	June 18	34	235	47	0.06	0.8	1.1	tr	78
7	Novaliches Plaza, between kms 17 and 18.	916	102	Aug. 3	28	235	42	0.04	0.6	0.57	tr	83
8	San Bartolome, Novaliches Road, between kms 16 and 17.	925	100	Aug. 8	26	270	39	1.6	1.4	27	9.7	49
9	Baisa Barrio, Balintawak, between kms 12 and 13.	950	107	Aug. 29	31	270	54	0.14	0.95	23	5	47
10	Mabini Street, near Sanfandanan.....	1472	123	June 6	34	275	71	0.08	0.78	12	3.2	69
11	Dulong Calzada, between kms 8 and 9.	1867	145	July 25	27	275	66	0.04	0.61	3.4	tr	62
12	Baisa Barrio, Balintawak, between kms 11 and 12.	---	---	Sept. 5	18	280	105	0.88	1.4	22	7.1	31
13	Novaliches Road, between kms 14 and 15.	938	84	Aug. 20	25	300	75	0.6	1	36	16	30.5
14	A. Mabini, between kms 8 and 9.	2478	124	Aug. 27	29	310	85	0.08	0.79	12	2.9	67
15	Sampalucan, A. Mabini, between kms 7 and 8.	695	191	July 16	30	320	33	0.07	0.58	2	tr	102
16	Talipapa, Balintawak, between kms 13 and 14.	2571	116	Aug. 24	27	330	94	0.32	1	36	16	34
17	Caloocan Plaza, near the municipal building.	105	218	Sept. 17	50	330	43	0.08	0.58	3.4	tr	110
18	A. Mabini, North Road, near km 9.	683	205	Sept. 28	13	330	63	0.22	0.90	4.9	1.4	100
19	A. Mabini, North Road, near km 7.	2469	84	Oct. 3	37	335	76	0.1	0.77	4.6	2.8	91
SAN JUAN DEL MONTE.												
SJ-1	Mariquina Road, between kms 7 and 8.	2354	157	Sept. 20	29	245	31	0.09	0.78	5.4	tr	74
2	Corner Blumentritt and Bonifacio.	---	---	Aug. 28	8	290	74	0.17	0.93	9.4	1.8	70
3	Market place.....	878	101	May 23	21	295	60	0.14	0.74	2.9	tr	92.4
4	Santa Lucia Barrio.....	1806	72	July 31	27	295	78	0.07	0.8	16	6.8	58

TABLE 1.—Mineral analyses of waters from artesian wells located in Manila and neighboring municipalities—Continued.

Tracing No.	Location.	Well No.	Depth of well; meters.	Date of collection of samples.	Capacity: liters per minute.	Total solids (at 180° C.).	Silica (SiO ₂).	Iron (Fe).	Aluminum (Al).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).
1	2	3	4	5	6	7	8	9	10	11	12	13
SAN JUAN DEL MONTE—Continued												
5	Rizal Street, near Burgos.....			1929 Sept. 9	30	295	72	0.08	0.79	8.2	2.4	71
6	Ermitaño Barrio, East Street.....	1744	55	Oct. 4	49	295	59	0.08	0.79	3.7	tr	80
7	Mariquina Road, Ermitaño Barrio, between kms 8 and 9.			July 2	34	300	62	0.1	1.2	8.6	tr	88
8	Broadway, near First Street, New Manila.....			Sept. 23	14	300	59	0.02	0.62	7.7	tr	83.5
9	Cubao Barrio, Mariquina Road, between kms 10 and 11.	1812	150	Sept. 13	31	305	79	0.32	1	17	5.2	65
10	Ortega Street Addition.....	2334	93	Aug. 2	36	320	72	0.04	0.6	2.3	tr	95
11	San Pedro Street near km 6, Mariquina Road	1730	93	Oct. 2	33	390	86	0.22	0.89	6.4	3.1	96
SAN FELIPE NERI.												
SF-1	Hagdaan Bato, Bonifacio Street.....	2535	120	Oct. 8	34	275	67	0.24	1.1	11	4	60
2	T. Kalazan, near river.....	1636	47	Sept. 26	38	295	78	0.29	0.84	27	9.9	41
3	Lamayvan, corner Rizal and Vergara.....	872	110	Oct. 1	35	300	59	0.08	0.78	4.3	tr	95
4	Blumentritt, between municipal building and school.	859	63	Aug. 1	23	305	86	0.28	1.1	26	8.5	43
5	Mabini Street.....	1840	126	Sept. 10	28	305	61	0.11	0.77	2.3	tr	86
6	Zanaga Barrio.....	2527	96	Aug. 6	38	310	69	0.15	0.74	5.2	tr	75
7	Jolo Barrio.....	2375	90	Aug. 19	26	310	61	0.11	0.76	0.86	tr	97
8	Barranca.....	1664	109	Sept. 14	30	315	71	0.1	0.56	17.5	4.8	68
9	Hagdaan Bato, corner A. Luna and Bonifacio.....	863	40	Aug. 21	27	325	100	0.12	0.97	34	15	26.6
10	Kalentong Street, between kms 9 and 10.....	1832	46	Sept. 7	31	335	90	0.19	0.71	22	8.5	58.5
11	Jolo Barrio, at J. Coronado.....	1712	106	Aug. 23	33	345	75	0.21	0.9	4.3	tr	94

12	Blumentritt Street, in front of market.....	798	270	July 30	24	495	63	0.27	1.1	5.4	tr	140
13	Lamayan Barrio, Segura and Rizal Streets.....	2520	130	Sept. 25	33	685	53	0.19	0.92	10	tr	204
SAN PEDRO MAKATI.												
SP-1	Guadalupe, McKinley Road, kms 7 and 8.....	1610	129	Aug. 7	34	225	42	0.1	0.77	4.9	tr	65
2	McKinley Road, between kms 6 and 7.....	802	108	July 27	33	230	37	0.08	0.79	0.86	tr	68
3	Guadalupe, Ninety-sixth Street.....	1622	84	Aug. 22	18	280	54	0.36	1.4	2	tr	80
4	J. Rizal and P. P. Roxas.....	258	171	June 29	31	285	50	0.08	0.4	5.7	tr	93
5	Olimpia Barrio, J. B. Roxas Street.....	786	129	Sept. 26	17	300	42	0.22	1.1	5.7	3.1	82.5
6	Bonifacio Street, 1 km east of the municipal building.....	2052	104	Oct. 3	36	305	52	0.14	0.74	1.7	tr	90
7	E. Zobel Street.....	814	124	Oct. 7	30	360	75	0.72	1.4	16	8.7	80
8	Cristal Barrio, in front of chapel.....	1995	220	Oct. 5	36	365	44	0.08	0.58	4.9	tr	100
9	Masilang Barrio, Soliman, near Comercio.....	841	128	Sept. 24	28	390	95	0.46	1.1	24	11	76.3
10	Tejeron Barrio, McKinley Road, kms 4 and 5.....	2013	109	Sept. 18	32	410	50	0.14	0.74	0.86	tr	129
11	Culicuti Barrio, near Batangas railroad track.....	1445	55	Aug. 10	33	415	98	4.3	1.9	29	12	75
12	Guadalupe, in front of Dapitan Street.....	1601	130	Sept. 6	22	420	85	0.27	0.64	23	4.3	94
PASAY.												
P-1	San Roque Barrio, corner Tolentino and Pro-tacio.....	732	69	Aug. 30	31	415	94	1.7	1.2	34	23	50
2	Malibay Barrio, corner of Jose Street, near chapel.....	877	149	Aug. 26	29	425	115	0.88	1	33	12	74
3	Santol Barrio, corner Protacio and Decena.....	765	179	Sept. 12	29	535	87	0.25	0.87	7.7	3.3	149
4	Leveriza, near Villaruel.....	768	108	July 29	29	585	80	0.12	0.76	5.4	3.8	172
5	Corner Tolentino and Aurora.....	444	92	Aug. 5	35	730	91	4.3	1.8	27	17	173
6	Zamora Street, corner of Apelo Cruz, Tabon.....	444	92	July 26	33	935	89	1.5	1.6	56	22	215
7	Tambo Barrio, at Camp Claudio.....	---	---	May 18	37	1,245	75	0.32	1.5	17	6.5	332

TABLE 1.—*Mineral analyses of waters from artesian wells located in Manila and neighboring municipalities—Continued.*

Tracing No.	Location.	Potassium (K).	Carbonate radical (CO ₃).	Bicarbonate radical (HCO ₃).	Sulphate radical (SO ₄).	Chloride radical (Cl).	Nitrate radical (NO ₃).	Free carbonate (CO ₂).	Total hardness (as CaCO ₃).	Chemical character.
1	2	14	15	16	17	18	19	20	21	22
MANILA.										
M-1	Santiago, near G. Tuson, Sampaloc.	18	18.7	43	29	35	0.2	---	4.3	Na-HCO ₃ .
2	Plaza Guipit, Sampaloc.	13	21.5	91	36	30	0.09	---	6.4	Na-HCO ₃ .
M-3	Plaza Moriones, Tondo.	9.4	20	81	44	38	0.07	---	5	Na-HCO ₃ .
4	Corner Victoria and Muralla Streets, Intramuros.	14	23	28	73	41	0.15	---	7.2	Na-SO ₄ .
5	San Lazaro Hospital.	3.6	23	54	66	42	---	---	2.1	Na-SO ₄ .
6	Eguerra, between Yangco and Franco Streets, Tondo.	20	8.5	20.6	16	26	0.09	---	4.3	Na-HCO ₃ .
7	Santa Mesa Market, at Teresa Street.	9.4	12	34	70	66	0.07	---	8.6	Na-SO ₄ .
8	Estado Street, between Benavides and Magdalena.	8.4	11	53	100	41	0.07	---	2.9	Na-SO ₄ .
9	San Lazaro Market, Blumentritt Street.	4.6	15	156	31	45	0.15	---	8.6	Na-HCO ₃ .
10	Santa Clara School, Andalucia Street.	11	27	66	39	75	0.18	---	3.6	Na-Cl.
11	Antonio Rivera, near Tayuman.	17	41	40	43	72	0.22	---	4.3	Na-Cl.
12	Manrique Street, in front of Sampaloc Church.	6.8	15	95	54	78	0.09	---	8.6	Na-HCO ₃ .
13	Jesus and Narciso Streets, Pandacan.	15	24	66	60	81	0.11	---	8.6	Na-Cl.
14	Plaza Miranda, at Quiapo Church.	17	3.8	70	93	130	0.07	---	9.3	Na-Cl.
15	O'Donnell, between Lope de Vega and Zurbaran.	15	12	117	41	170	0.14	---	25	Na-Cl.
16	Anak Bayan, Paco.	16	7.3	330	60	42	0.11	---	10	Na-HCO ₃ .
17	Del Pan, San Nicolas.	35	1.2	314	10	125	0.15	---	32	Na-HCO ₃ .
18	Paco Market, Dart and Herran Streets.	23	---	470	8.6	73	0.18	4.3	36	Na-HCO ₃ .
19	Santa Ana Market, Calderon Street.	16	7	112	145	225	0.06	---	25	Na-Cl.
20	Engineer Island.	36.2	14	23	77	390	0.13	---	39	Na-Cl.
21	Plaza de la Virgen, Pandacan.	35	---	155	250	240	0.14	2	46	Na-SO ₄ .
22	Malate Market, Leveriza Street.	96	5.1	55	225	390	0.06	---	46	Na-Cl.

CALOOCAN									
C-1	Novaliches Road, between kms 10 and 11.....	6.2	19.7	125	0.83	5	0.07	---	14 Na-HCO ₃ .
2	Balon Bato, Novaliches Road, between kms 9 and 10.....	7.2	24.9	111	2.5	6.5	0.13	---	7.1 Na-HCO ₃ .
3	Cangcong Barrio, Novaliches Road, between kms 8 and 9.....	8.8	16.4	135	13	8	0.09	---	18 Na-HCO ₃ .
4	Rizal Avenue extension, between kms 6 and 7.....	2.7	17	156	7.4	9.6	0.09	---	13 Na-HCO ₃ .
5	Balintawak, near km 9.....	11	19.8	135	16	10	0.11	---	10 Na-HCO ₃ .
6	Novaliches Road, between kms 17 and 18.....	4.5	28	149	3.1	4	0.06	---	2.9 Na-HCO ₃ .
7	Novaliches Plaza, between kms 17 and 18.....	5.4	28.3	145	2.8	4.8	0.62	---	1.4 Na-HCO ₃ .
8	San Bartolome, Novaliches Road, between kms 16 and 17.....	8.5	---	260	tr	7.7	0.49	2	110 Na-HCO ₃ .
9	Baissa Barrio, Balintawak, between kms 12 and 13.....	19	---	238	do.	6.7	0.53	2	77 Na-HCO ₃ .
10	Mabini Street, near Sagandaan.....	7.3	0.6	205	5.9	13	0.04	---	44 Na-HCO ₃ .
11	Dulong Calzada, between kms 8 and 9.....	26	13	148	15.7	12	0.09	---	8.6 Na-HCO ₃ .
12	Baissa Barrio, Balintawak, between kms 11 and 12.....	10.5	---	180	3.6	9.6	0.11	29	85 Na-HCO ₃ .
13	Novaliches Road, between kms 14 and 15.....	6.4	---	270	tr	5.8	0.09	4	160 Ca-HCO ₃ .
14	A. Mabini, between kms 8 and 9.....	13	1.9	205	8.6	17	0.09	---	42 Na-HCO ₃ .
15	Sampalucan, A. Mabini, between kms 7 and 8.....	15.5	15	210	27	14	0.14	---	5 Na-HCO ₃ .
16	Talipapa, Balintawak, between kms 13 and 14.....	7.4	---	280	tr	6.7	0.09	5.9	155 Ca-HCO ₃ .
17	Caloocan Plaza, near the municipal building.....	15.5	14.1	230	21	14	0.11	---	8.6 Na-HCO ₃ .
18	A. Mabini, North Road, near km 9.....	11.5	16.4	220	19	13	0.09	---	18 Na-HCO ₃ .
19	A. Mabini, North Road, near km 7.....	14	---	250	6.6	18	0.09	2	23 Na-HCO ₃ .
SAN JUAN DEL MONTE.									
SJ-1	Mariquina Road, between kms 7 and 8.....	6	15.3	100	33	28	0.09	---	14 Na-HCO ₃ .
2	Corner Blumentritt and Bonifacio.....	12.5	5.6	210	4.8	7.7	0.15	---	31 Na-HCO ₃ .
3	Market place.....	6.8	27	173	8.1	14	0.16	---	7.2 Na-HCO ₃ .
4	Santa Lucia Barrio.....	8	1.2	228	4.9	7.7	0.19	---	67 Na-HCO ₃ .
5	Rizal Street, near Burgos.....	14.5	4.8	215	6.1	8.6	0.07	---	30 Na-HCO ₃ .
6	Ermitaño Barrio, East Street.....	13	13	179	11	14	0.07	---	9.2 Na-HCO ₃ .
7	Mariquina Road, Ermitaño Barrio, between kms 8 and 9.....	12	1.2	222	6.6	11	0.58	---	21 Na-HCO ₃ .
8	Broadway, near First Street, New Manila.....	12.5	4.8	235	4.4	8.1	0.04	---	19 Na-HCO ₃ .
9	Cubao Barrio, Mariquina Road, between kms 10 and 11.....	9	2.4	245	1.5	7.0	0.15	---	63 Na-HCO ₃ .
10	Ortega Street addition.....	12	18.7	205	7.1	11	0.09	---	5.7 Na-HCO ₃ .
11	San Pedro Street, near km 6, Mariquina Road.....	30	---	285	3.6	27	0.07	4	16 Na-HCO ₃ .

TABLE 1.—*Mineral analyses of waters from artesian wells located in Manila and neighboring municipalities—Continued.*

Tracing No.	Location.	Potassium (K).	Carbonate radical (CO ₃).	Bicarbonate radical (HCO ₃).	Sulphate radical (SO ₄).	Chloride radical (Cl).	Nitrate radical (NO ₃).	Free carbon dioxide (CO ₂).	Total hardness (as CaCO ₃).	Chemical character.
1	2	14	15	16	17	18	19	20	21	22
SAN FELIPE NERI.										
SF-1	Hagdaan Bato, Bonifacio Street.	16.5	---	210	6.9	10	0.07	2	43	Na-HCO ₃ .
2	T. Kalazan, near river.	8.4	---	230	0.82	7	0.09	4	110	Na-HCO ₃ .
3	Lamayan, corner Rizal and Vergara.	7.5	17.5	205	6.1	12	0.07	11	11	Na-HCO ₃ .
4	Blumentritt, between municipal building and school.	11	---	235	tr.	9.6	0.20	5.9	100	Na-HCO ₃ .
5	Mabini Street.	14	15.3	175	13	20	0.14	---	5.7	Na-HCO ₃ .
6	Zanaga Barrio.	24	3.6	205	7.9	16	2.21	---	13	Na-HCO ₃ .
7	Jolo Barrio.	12	10.7	220	10.4	11	0.18	---	2.1	Na-HCO ₃ .
8	Barranca.	12.5	3.6	250	3.3	9	0.11	---	63	Na-HCO ₃ .
9	Hagdaan Bato, corner A. Luna and Bonifacio.	10	---	212	1.8	27	5.31	19	150	Ca-HCO ₃ .
10	Kalentong Street, between kms 9 and 10.	10.5	---	260	3.3	9.6	0.04	3	91	Na-HCO ₃ .
11	Jolo Barrio, at J. Coronado.	12	28.4	110	29	43	0.11	---	11	Na-HCO ₃ .
12	Blumentritt Street, in front of market.	18	13	59	150	77	0.09	---	14	Na-SO ₄ .
13	Lamayan Barrio, Segura and Rizal Streets.	42	7.4	155	20	255	0.07	---	25	Na-Cl.
SAN PEDRO MAKATI.										
SP-1	Guadalupe, McKinley Road, kms 7 and 8.	13	18.7	125	10	12	0.44	---	12	Na-HCO ₃ .
2	McKinley Road, between kms 6 and 7.	15.4	16	127	16	14	0.2	---	2.1	Na-HCO ₃ .
3	Guadalupe, Ninety-sixth Street.	14	14.1	170	15	13	0.27	---	5	Na-HCO ₃ .
4	J. Rizal and P. P. Roxas.	7.3	20	54	48	41	0.09	---	14	Na-HCO ₃ .
5	Olimpia Barrio, J. B. Roxas Street.	20	9	180	16	37	0.07	---	27	Na-HCO ₃ .
6	Bonifacio Street, 1 km east of the municipal building.	22.6	10.7	222	6.1	16	0.04	---	4.3	Na-HCO ₃ .
7	E. Zobel Street.	15.5	---	301	2.5	14	tr.	5	75	Na-HCO ₃ .
8	Cristal Barrio, in front of chapel.	27	17	104	55	66	0.07	---	12	Na-HCO ₃ .
9	Masilang Barrio, Soliman, near Comercio.	6.9	---	310	7.6	12	0.11	11	105	Na-HCO ₃ .

10	Tejeron Barrio, McKinley Road, kms 4 and 5.	18	7.3	180	40	74	0.07	2.1	Na-HCO ₃ .
11	Culiculi Barrio, near Batangas railroad track.	10.5	---	347	tr	---	0.24	18	Na-HCO ₃ .
12	Guadalupe, in front of Dapitan Street.	19	---	325	13	17.5	0.11	4	Na-HCO ₃ .
PASAY.									
P-1	San Roque Barrio, corner Tolentino and Protacio.	16	---	335	tr	---	0.11	25	Na-HCO ₃ .
2	Malibay Barrio, corner of Jose Street, near chapel.	12	---	350	1.3	9.5	0.04	17	Na-HCO ₃ .
3	Santol Barrio, corner Protacio and Decena.	25	4.8	310	50	52	0.14	33	Na-HCO ₃ .
4	Leveriza, near Villaruel.	34	3.4	332	16	110	0.09	29	Na-HCO ₃ .
5	Corner Tolentino and Aurora.	36	---	350	9.4	185	0.11	16	Na-HCO ₃ .
6	Zamora Street, corner of Apelo Cruz, Tabon.	43	---	324	15	335	0.11	12	Na-Cl.
7	Tambo Barrio, at Camp Claudio.	125	---	246	115	445	0.04	3.2	Na-Cl.

TABLE 2.—Mineral analyses of waters from artesian wells located in Manila and neighboring municipalities.

[Hypothetical form of combination. Results in milligrams per liter.]

Trading No.	Location.	Potassium chloride (KCl).	Sodium chloride (NaCl).	Sodium sulphate (Na ₂ SO ₄).	Sodium nitrate (NaNO ₃).	Sodium carbonate (Na ₂ CO ₃).	Sodium bicarbonate (NaHCO ₃).	Magnesium bicarbonate (Mg(HCO ₃) ₂).	Calcium bicarbonate (Ca(HCO ₃) ₂).	Sodium silicate (Na ₂ SiO ₃).
1	2	2	3	4	5	6	7	8	9	10
MANILA.										
M-1	Santiago, near G. Tuason, Sampaloc.	34.3	30.9	42.8	0.274	33.1	59.2	---	---	6.4
2	Plaza Guipit, Sampaloc.	24.8	30.1	53.2	0.123	37.7	114.5	---	10.5	---
3	Plaza Moriones, Tondo.	17.9	48.7	65.1	0.096	35.3	103.7	---	8.2	---
4	Corner Victoria and Muralla Streets, Intramuros.	26.7	46.7	108.1	0.206	40.6	38.6	---	---	9.3
5	San Lazaro Hospital.	6.9	63.8	97.7	---	40.6	74.6	---	---	---
6	Esguerra, between Yangco and Franco Streets, Tondo.	38.1	12.9	23.7	0.123	15.1	275.7	---	7.4	---
7	Santa Mesa market, at Teresa Street.	17.9	94.9	103.6	0.096	21.2	46.8	---	---	10.6
8	Estado Street, between Benavides and Magdalena.	16	55.1	147.9	0.096	19.4	73	---	---	44.8
9	San Lazaro market, Blumentritt Street.	8.8	67.3	45.9	0.206	26.5	215.3	---	---	---

TABLE 2.—Mineral analyses of waters from artesian wells located in Manila and neighboring municipalities—Continued.

Tracing No.	Location.	Potassium chloride (KCl).	Sodium chloride (NaCl).	Sodium sulphate (Na ₂ SO ₄).	Sodium nitrate (NaNO ₃).	Sodium carbonate (Na ₂ CO ₃).	Sodium bicarbonate (NaHCO ₃).	Magnesium bicarbonate Mg (HCO ₃) ₂ .	Calcium bicarbonate Ca (HCO ₃) ₂ .	Sodium silicate (Na ₂ SiO ₃).
1	2	2	3	4	5	6	7	8	9	10
MANILA—Continued.										
10	Santa Clara School, Andalucia Street.....	21.1	107.2	57.7	0.248	47.7	85.4	---	5.6	---
11	Antonio Rivera, near Tayuman.....	32.4	98.4	63.6	0.302	72.5	48.2	---	6.7	---
12	Manrique Street, in front of Sampaloc Church.....	12.9	118.5	79.9	0.123	26.5	130.8	---	---	8.2
13	Jesus and Narciso Streets, Pandacan.....	28.6	111.2	88.8	0.151	42.4	90.9	---	---	---
14	Plaza Miranda, at Quiapo Church.....	32.4	189.1	137.6	0.096	6.7	80.7	tr	15.1	---
15	O'Donnell, between Lope de Vega and Zurbaran.....	28.6	258.1	60.7	0.192	21.2	161.1	---	---	---
16	Anak Bayan, Paco.....	30.5	45.4	88.8	0.151	12.9	454.4	---	---	21.8
17	Del Pan, San Nicolas.....	66.8	153.7	14.8	0.208	2.1	396.8	16.2	16.6	---
18	Paco Market, Dart and Herran Streets.....	43.9	86.1	12.6	0.247	---	584.1	24.1	34.6	---
19	Santa Ana Market, Calderon Street.....	30.5	347.5	214.6	0.082	12.4	113.6	---	89.5	---
20	Engineer Island.....	69.1	589.1	113.9	0.178	24.7	---	---	30.5	---
21	Plaza de la Virgen, Pandacan.....	66.8	343.7	370	0.192	---	133.6	---	77.1	---
22	Malate Market, Leveriza Street.....	183	500	333	0.085	9.1	---	---	72.8	---
CALOOCAN.										
C-1	Novaliches Road, between kms 10 and 11.....	10.5	---	* 1.5	0.096	33.1	149.8	---	21.5	---
2	Balon Bato, Novaliches Road, between kms 9 and 10.....	13.7	---	3.7	0.178	44.1	141.3	---	11.3	---
3	Gangcong Barrio, Novaliches Road, between kms 8 and 9.....	16.8	---	19.2	0.123	29.3	159.7	12.6	11.3	---
4	Rizal Avenue extension, between kms 6 and 7.....	5.1	11.9	10.9	0.124	30.1	194.1	---	21.1	---
5	Balintawak, near km 9.....	21	---	23.7	0.154	35	169.3	---	16.1	---
6	Novaliches Road, between kms 17 and 18.....	8.6	---	4.6	0.082	49.5	200.7	---	4.4	---
7	Novaliches Plaza, between kms 17 and 18.....	10.2	---	4.1	0.850	50	199.7	---	---	14.1
8	San Bartolome, Novaliches Road, between kms 16 and 17.....	16.2	---	---	0.672	---	178.9	58.2	109.2	---

TABLE 2.—Mineral analyses of waters from artesian wells located in Manila and neighboring municipalities—Continued.

Tracing No.	Location.	Potassium chloride (KCl).	Sodium chloride (NaCl).	Sodium sulphate (Na ₂ SO ₄).	Sodium nitrate (NaNO ₃).	Sodium carbonate (Na ₂ CO ₃).	Sodium bicarbonate (NaHCO ₃).	Magnesium bicarbonate (HCO ₃) ₂ .	Calcium bicarbonate Ca(HCO ₃) ₂ .	Sodium silicate (Na ₂ SiO ₃).
1	2	2	3	4	5	6	7	8	9	10
SAN FELIPE NERI—Continued.										
8	Barranca.....	18.9	---	* 6.1	0.151	6.4	238.1	28.8	70.7	---
9	Hagdaan Bato, corner A. Luna and Bonifacio.....	19.7	28.5	2.7	7.289	---	45.9	90.1	137.6	---
10	Kalontong Street, between kms 9 and 10.....	20.1	---	4.9	0.065	---	207.1	51.1	89.1	---
11	Jolo Barrio, at J. Coronado.....	22.9	52.9	42.9	0.151	51	133.5	---	17.4	---
12	Blumentritt Street, in front of market.....	34.3	100.1	222.1	0.123	23.1	67.8	---	13.1	---
13	Lamayán Barrio, Segura and Rizal Streets.....	80.1	357.9	29.6	0.091	13.1	171.6	---	40.4	---
SAN PEDRO MAKATI.										
SP-1	Guadalupe, McKinley Road, between kms 7 and 8.....	25	---	14.8	0.604	33	170.9	---	---	---
2	McKinley Road, between kms 6 and 7.....	29.4	---	23.7	0.274	28.3	175.2	---	---	---
3	Guadalupe, Ninety-sixth Street.....	27	---	22.2	0.370	24.9	225.9	---	8.1	---
4	J. Rizal and P. P. Roxas.....	13.9	56.8	71	0.124	35.3	74.3	---	---	31.6
5	Olimpia Barrio, J. B. Roxas Street.....	38.1	31.2	23.7	0.096	15.9	203.2	18.6	23.1	---
6	Bonifacio Street, 1 km east of municipal building.....	3.6	---	* 11.1	0.056	18.9	298.8	---	6.7	---
7	El Zobel Street.....	29.5	---	3.7	tr.	---	287.8	52.2	64.6	---
8	Cristal Barrio, in front of chapel.....	51.5	68.5	81.4	0.096	30.1	122.3	---	19.8	---
9	Masilang Barrio, Soliman, near Comercio.....	13.1	10.3	11.2	0.151	---	249.2	66	98.2	---
10	Tejeron Barrio, McKinley Road, kms 4 and 5.....	34.3	95.2	59.2	0.096	12.9	244.2	---	3.5	---
11	Culiculi Barrio, near Batangas railroad track.....	20.1	---	---	0.329	---	273.7	72.1	117.3	---
12	Guadalupe, in front of Dapitan Street.....	36.5	---	19.2	0.151	---	321.1	25.8	93.3	---
PASAY.										
P-1	San Roque Barrio, corner Tolentino and Protacio.....	30.5	14.1	---	0.151	---	160.7	138.1	137.3	tr.
2	Mailbay Barrio, C. José Street, near chapel.....	20.1	---	* 2.8	0.055	---	270.1	72	124.5	---
3	Santol Barrio, corner Protacio and Decena.....	47.7	48.4	74.1	0.192	8.5	372.2	19.8	31.2	---

4	Leveriza, near Villaruel.....	64.8	130.7	23.7	0.123	6.1	407.2	22.8	21.8
5	Corner Tolentino and Aurora.....	68.6	251.4	13.9	0.151	-----	252.5	102	109.2
6	Zamora Street, corner Apelo Cruz, Tabon.....	82.1	487.1	22.2	0.151	-----	60.3	132.1	226.2
7	Tambo Barrio, at Camp Claudio.....	238.2	547.4	170.2	0.055	-----	223.2	39	68.6
Tracing No.	Location.	Calcium silicate (CaSiO ₃).	Iron oxide and alumina (FeO ₂ +Al ₂ O ₃).	Silica (SiO ₂).	Oxygen to form SiO ₂ .	Classification.			
1	2	11	12	13	14	15			
M-1	MANILA.								
	Santiago, near G. Tuason, Sampaloc.....	4.9	1.2	22.3	1.5	Very mild. Sodic bicarbonated (muriated) alkaline—saline.			
2	Plaza Guipit, Sampaloc.....	-----	1.6	30	-----	Very mild. Sodic bicarbonated alkaline.			
3	Plaza Moriones, Tondo.....	-----	1.6	24	-----	Do.			
4	Corner Victoria and Muralla Streets, Intramuros.....	8.4	3.6	17.1	2.7	Very mild. Sodic sulphated saline.			
5	San Lazaro Hospital.....	2.5	1.6	28.7	0.3	Mild. Sodic sulphated (bicarbonated) alkaline—saline.			
6	Esguerra, between Yangco and Franco Streets, Tondo.....	-----	1.6	34	-----	Mild. Sodic bicarbonated alkaline.			
7	Santa Mesa market, at Teresa Street.....	9.9	1.6	29.7	2.8	Mild. Sodic sulphated (muriated) saline.			
8	Estado Street, between Benavides and Magdalena.....	3.2	2	30.3	6.3	Very mild. Sodic sulphated saline.			
9	San Lazaro market, Blumentritt Street.....	9.9	2	60	1.4	Mild. Sodic bicarbonated alkaline.			
10	Santa Clara School, Andalucia Street.....	-----	1.6	74.1	-----	Mild. Sodic muriated (bicarbonated) alkaline—saline.			
11	Antonio Rivera, near Tayuman.....	-----	1.2	70	-----	Very mild. Sodic muriated (bicarbonated) alkaline—saline.			
12	Manrique Street, in front of Sampaloc Church.....	9.9	1.6	40.9	2.4	Very mild. Sodic bicarbonated (muriated) alkaline—saline.			
13	Jesus and Narciso Streets, Pandacan.....	9.9	2	58.9	1.3	Mild. Sodic muriated (bicarbonated) alkaline—saline.			
14	Plaza Miranda, at Quiapo Church.....	-----	2.4	60	-----	Mild. Sodic muriated (sulphated) saline.			
15	O'Donnell, between Lope de Vega and Zurbaran.....	29	2	46	4	Mild. Sodic muriated saline.			
16	Anak Bayan, Paco.....	11.6	2.4	52.3	4.5	Mild. Sodic bicarbonated alkaline.			
17	Del Pan, San Nicolas.....	12.2	1.6	76.7	1.7	Do.			
18	Paco Market, Dart and Herran Streets.....	-----	2.4	77	-----	Strong. Sodic bicarbonated alkaline.			

* K₂SO₄.

TABLE 2.—*Mineral analyses of waters from artesian wells located in Manila and neighboring municipalities—Continued.*

Trading No.	Location.	Calcium silicate (CaSiO ₃).	Iron oxide and alumina (Fe ₂ O ₃ + Al ₂ O ₃).	Silica (SiO ₂).	Oxygen to form SiO ₂ .	Classification.
1	2	11	12	13	14	15
MANILA—Continued.						
19	Santa Ana Market, Calderon Street.....	---	2	57	---	Strong. Sod. muriated (sulphated) saline.
20	Engineer Island.....	24.7	1.6	53.2	3.4	Strong. Sod. muriated saline.
21	Plaza de la Virgen, Pandacan.....	---	2.4	55	---	Strong. Sod. sulphated (muriated) saline.
22	Malate Market, Leveriza Street.....	---	2.4	68	---	Strong. Sod. muriated (sulphated) saline.
CALOOCAN.						
C-1	Novaliches Road, between kms 10 and 11.....	---	1.6	23	---	Very mild. Sod. bicarbonated alkaline.
2	Balon Bato, Novaliches Road, between kms 9 and 10	---	1.6	26	---	Do.
3	Cangcong Barrio, Novaliches Road, between kms 8 and 9.	2.6	2	35.7	0.4	Mild. Sod. bicarbonated alkaline.
4	Rizal Avenue extension, between kms 6 and 7.....	---	0.8	20	---	Do.
5	Balintawak, near km 9.....	---	2	32	---	Do.
6	Novaliches Road, between kms 17 and 18.....	---	1.6	47	---	Do.
7	Novaliches Plaza, between kms 17 and 18.....	1.7	1.2	34.3	2.1	Do.
8	San Bartolome, Novaliches Road, between kms 16 and 17.	---	4.8	39	---	Mild. Sod. (calcic) bicarbonated alkaline.
9	Baisa Barrio, Balintawak, between kms 12 and 13.....	---	2	54	---	Mild. Sod. bicarbonated alkaline.
10	Mabini Street, near Sañgandaan.....	10.7	1.6	65.5	1.5	Do.
11	Dulong Calzada, between kms 8 and 9.....	---	1.2	66	---	Do.
12	Baisa Barrio, Balintawak, between kms 11 and 12.....	---	3.6	105	---	Mild. Sod. (calcic) bicarbonated alkaline.
13	Novaliches Road, between kms 14 and 15.....	---	2.8	75	---	Mild. Calcic (sodic) bicarbonated alkaline.
14	A. Mabini, between kms 8 and 9.....	---	1.6	85	---	Mild. Sod. bicarbonated alkaline.
15	Sampalucan, A. Mabini between kms 7 and 8.....	---	1.2	33	---	Do.
16	Talipapa, Balintawak, between kms 13 and 14.....	---	2.4	94	---	Mild. Calcic (sodic) bicarbonated alkaline.

17	Caloocan Plaza, near municipal building.....				42.2	0.8	Mild. Sod. bicarbonated alkaline.
18	A. Mabini, North Road, near km 9.....	9.6	1.2	2	58.1	1.2	Do.
19	A. Mabini, North Road, near km 7.....	2	1.6		75	0.3	Do.
SAN JUAN DEL MONTE.							
SJ-1	Mariquina Road, between kms 7 and 8.....		1.6		31		Very mild. Sod. bicarbonated alkaline.
2	Corner Blumentritt and Bonifacio.....		2		74		Mild. Sod. bicarbonated alkaline.
3	Market place.....		1.6		60		Do.
4	Santa Lucia Barrio.....		1.6		73		Do.
5	Rizal Street, near Burgos.....		1.6		72		Do.
6	Ermitaño Barrio, East Street.....		1.6		59		Do.
7	Mariquina Road, Ermitaño Barrio, between kms 8 and 9.....	24.9	2.4		49.1	3.4	Do.
8	Broadway, near First Street, New Manila.....		1.2		59		Do.
9	Cubao Barrio, Mariquina Road, between kms 10 and 11.....		2.4		79		Do.
10	Ortega Street addition.....	6.7	1.2		68.5	0.9	Do.
11	San Pedro Street, near km 6, Mariquina Road.....		2		86		Do.
SAN FELIPE NERI.							
SF-1	Hagdaan Bato, Bonifacio Street.....	2.3	2.4		65.8	0.3	Do.
2	T. Kalazan, near river.....	9.9	2		72.9	1.4	Very mild. Sod. bicarbonated alkaline.
3	Lamayán, corner of Rizal and Vergara.....	7.8	1.6		55	1.1	Mild. Sod. bicarbonated alkaline.
4	Blumentritt, between municipal building and school.....		2.4		86		Mild. Sod. (calcic) bicarbonated alkaline.
5	Mabini Street.....		1.6		61		Mild. Sod. bicarbonated alkaline.
6	Zanega Barrio.....		1.6		69		Do.
7	Jolo Barrio.....		1.6		59.7		Do.
8	Barranca.....	2.5	1.6		71	0.3	Do.
9	Hagdaan Bato, corner A. Luna and Bonifacio.....		2		100		Mild. Calcic bicarbonated alkaline.
10	Kalentong Street, between kms 9 and 10.....		1.6		90		Mild. Sod. bicarbonated alkaline.
11	Jolo Barrio, at J. Coronado.....		2		75		Very mild. Sod. bicarbonated alkaline.
12	Blumentritt Street, in front of market.....	6.4	2.4		59.7	0.9	Mild. Sod. sulphated saline.
13	Lamayán Barrio, Segura and Rizal Streets.....		2		53		Mild. Sod. muriated saline.

TABLE 2.—Mineral analyses of waters from artesian wells located in Manila and neighboring municipalities—Continued.

Tracing No.	Location.	Calcium silicate (CaSiO ₃).	Iron oxide and alumina (Fe ₂ O ₃ +Al ₂ O ₃).	Silica (SiO ₂).	Oxygen to form SiO ₂ .	Classification.
1	2	11	12	13	14	15
SAN PEDRO MAKATI.						
SP-1	Guadalupe, McKinley Road, between kms 7 and 8.	14.2	1.6	34.6	1.9	Mild. Sod. bicarbonated alkaline.
2	McKinley Road, between kms 6 and 7.	2.5	1.6	35.7	0.3	Do.
3	Guadalupe, Ninety-sixth Street.		3.2	54		Do.
4	J. Rizal and P. P. Roxas.	16.5	0.8	25.8	6.3	Very mild. Sod. bicarbonated (muriated) alkaline—saline.
5	Olimpia Barrio, J. B. Roxas Street.		2.4	42		Mild. Sod. bicarbonated alkaline.
6	Bonifacio Street, 1 km east of municipal building.		1.6	52		Do.
7	El. Zobel Street.		3.6	75		Do.
8	Cristal Barrio, in front of chapel.		1.2	44		Mild. Sod. bicarbonated (sulphated) alkaline—saline.
9	Masilang Barrio, Soliman, near Comercio.		2.8	95		Mild. Sod. bicarbonated alkaline.
10	Tejeron Barrio, McKinley Road, kms 4 and 5.		1.6	50		Do.
11	Culculi Barrio, near Batangas railroad track.		10.4	98		Do.
12	Guadalupe, in front of Dapitan Street.		1.6	85		Do.
PASAY.						
P-1	San Roque Barrio, corner Tolentino and Protacio.		4.8	94		Mild. Sod. (magnesian calcic) bicarbonated alkaline.
2	Malibay Barrio, corner of José Street, near chapel.	6.4	3.2	111.7	0.9	Strong. Sod. (calcic) bicarbonated alkaline.
3	Santol Barrio, corner Protacio and Decena.		2	87		Mild. Sod. bicarbonated alkaline.
4	Leveriza, near Villaruel.		1.6	80		Do.
5	Corner Tolentino and Aurora.		9.6	91		Strong. Sod. bicarbonated (muriated) alkaline—saline.
6	Zamora Street, corner Apelo Cruz, Tabon.		5.2	89		Mild. Sod. muriated saline.
7	Tambo Barrio, at Camp Claudio.		3.2	75		Strong. Sod. (potassic) muriated saline.

* K₂SO₄.b KHCO₃-29.7, the rest is NaHCO₃.

manner: "Two waters which carried the same substance in solution would be classed the same, although the one might contain 200 and the other, 20,000 parts per million of total dissolved matter." In view of this apparent anomaly it was thought advisable to adopt a slightly modified form of classification which will give the reader an idea, not only of the kind but also of the approximate concentration of the predominating constituents.

The following ratings give the same limiting values as adopted by Ellis and Lee,⁴⁴ with the difference that in this work they represent the concentration of the predominating constituents, and not the total mineralization of the waters.

The term "very mild" is applied to waters having a concentration of 150 parts per million or less of the predominating constituent or the sum of the predominating constituents; "mild," to waters in which the concentration is between 150 and 500; "strong," between 500 and 2,000; and "very strong," over 2,000.

Haywood-Smith classification.

Class.	Subclass.		
I. Alkaline	Carbonated or bicarbonated.	Sodic.	} Nongaseous. Carbondioxated. Sulphuretted. Azotized. Carbureted. Oxygenated.
	Borated.	Lithic.	
	Silicated.	Potassic.	
	Sulphated.	Calcic.	
II. Alkaline-saline	Muriated.	Magnesian.	
	Nitrated.	Ferruginous.	
	Sulphated.	Aluminic.	
	Muriated.	Arsenic.	
III. Saline	Nitrated.	Bromic.	
	Sulphated.	Iodic.	
IV. Acid	Muriated.	Silicious.	
		Boric.	

In the light of the preceding discussion in which it was pointed out that the least-mineralized waters are the best for human consumption, the waters cited in the following tables are arranged according to their mineralization; that is, for each municipality, the order is from the least- to the highest-mineralized well water.

The numbers and depths of the wells were kindly furnished by F. W. McCaw, superintendent of artesian wells, Bureau of Public Works.

On the attached sketch of Manila and vicinity (Plate 1) the locations of the wells have been marked and numbered. The numbers correspond to the tracing numbers in the tables.

DISCUSSION OF RESULTS

In general, the waters are characterized by the preponderance of sodium salts, a great proportion of which are in the form of sodium bicarbonate, some in the form of sodium chloride, and a few in the form of sodium sulphate. The presence of relatively small quantities of calcium and magnesium salts is also evident, indicating the general soft character of the underground waters within the territory included in this work. The average quantity of total dissolved solids is much lower than 500 parts per million, a quantity that, according to Buswell,⁴⁵ imparts to the water a salty or brackish taste, detectible by most people.

Rating these waters by total solids after the method of Ellis and Lee,⁴⁶ seventy of the eighty-four samples fall under the rating of moderately mineralized waters and fourteen under the rating of highly mineralized waters. It is interesting to note that all the highly mineralized waters, with the exception of one from San Felipe Neri, were obtained from artesian wells located in Manila and in the municipality of Pasay; and all the artesian waters in Manila having a mineralization above 600 parts per million are located south of Pasig River. Chlorine (as chloride) is the predominating constituent of many of these waters. Both Manila and Pasay are located nearer the sea on a relatively lower level than the neighboring municipalities.

In the course of this survey work, it has been also observed that some waters, which would be classed as highly mineralized, are considered good and palatable by those that use them, and the wells are usually crowded with people drawing water for drinking use at all hours of the day and until late at night. This is especially true of wells M-18 and P-4. In these well waters the sodium and bicarbonic acid radicals are present in relatively much larger quantities than the other constituents, placing them under the group of sodic bicarbonated waters. Two other well waters, marked M-22 and P-7, although of much higher total-solid content, would also be considered, according to Ellis and Lee's method, under the same rating as M-18 and P-4; but unlike these two wells, they are not popular with the

⁴⁵ The Chemistry of Water and Sewage Treatment. The Chem. Cat. Co. New York (1928) 71.

⁴⁶ U. S. Geol. Surv. Water-Supply Paper 446 (1919) 228.

people living in the neighborhood. Their predominating constituents are sodium and chlorine radicals, placing them under the group of sodic muriated waters. It is evident that, for the majority of the people, highly mineralized sodic bicarbonated waters are more acceptable for drinking purposes than sodic muriated waters of approximately the same mineralization. Well M-22 is also characterized by the presence of abnormal quantities of sodium sulphate, containing the SO_4 radical in the amount of 225 parts per million. This amount is above the minimum medicinal concentration given by Dole⁴⁷ in his discussion on the therapeutic action of certain inorganic radicals. This minimum concentration is 150 milligrams per kilogram or 150 parts per million.⁴⁸ The waters from wells M-21 and SF-12, containing 250 and 150 SO_4 radical in parts per million, respectively, may be also considered of similar character, with the difference that in this case the SO_4 radical predominates over the Cl radical placing the waters under the group of sodic sulphated waters.

Salty waters, containing sodium chloride below 500 parts per million, according to Dole,⁴⁹ will not interfere with normal osmosis. With the exception of well waters M-22 and P-7, M-22 containing 500 parts per million and P-7, 547.4 parts per million, the salt content of the rest of the well waters examined is below the above limit.

About 77 per cent of the wells were found to furnish sodic bicarbonated waters. Dole⁵⁰ believes that the smallest concentration of sodium in sodium bicarbonate that would possess therapeutic action is 35 milligrams per kilogram, or 35 parts per million. This quantity computed in the form of sodium bicarbonate (NaHCO_3) is equivalent to about 130 parts per million. Of the well waters examined 72.5 per cent contain sodium bicarbonate in amounts larger than this minimum concentration. The well waters containing the highest concentration of sodium bicarbonate are located in Manila; they are from wells M-18, M-16, and M-17; the sodium bicarbonate content of these waters is 584.1, 454.4, and 396.8 parts per million, respectively.

⁴⁷ U. S. Geol. Surv. Mineral Resources of the U. S. Washington (1912) 1182.

⁴⁸ This concentration given by Dole is based upon the assumption that a person, under usual conditions, drinks 4 kilograms of water per day.

⁴⁹ *Op. cit.* 1184.

⁵⁰ *Loc. cit.*

The calcium and magnesium radicals are present in small quantities only, possibly due to the fact that the wells are located within the region of soft underground waters. In the majority of the wells only traces of magnesium are found. Although very little distinctive action is usually assigned to the calcium radical, the minimum average concentration that would produce therapeutic action is 50 milligrams per kilogram, or 50 parts per million. Only well water P-6, has a little higher concentration of calcium radical than the above minimum limit.

Potassium, according to Cushny, arrests the action of the heart when introduced into the blood,⁵¹ but it has practically no such action when entering the stomach, because it is rapidly excreted in the urine. In view of this opinion, it may be concluded that the potassium salts in the amount they are present in the waters examined have no therapeutic action upon persons that drink these waters.

None of the waters would be strictly classified as hard waters. The highest quantity of total hardness encountered is 230 parts per million (P-29). Although the average limit given by different authors is 200 to 300 parts per million, in the Philippine Islands this limit would be considered fairly rigid.

The average hardness (parts per million) of the waters by municipalities is as follows: In Manila, 15.5; in Caloocan, 42.3; in San Juan del Monte, 49.1; in San Pedro Makati, 37.7; in Pasay, 115.1. These waters, with the exception of those in Pasay, may be considered of similar character, as to degree of hardness to those in North America, located in the following states: All the New England States, the Atlantic States, three southern states (Louisiana, Mississippi, Alabama), and in the Northwest, Washington and Oregon. McDonnell⁵² states that the average hardness of the waters in these localities is less than 50 parts per million.

The depths of the wells and the rates of flow have no apparent relation to the total mineralization or the chemical characters of the waters.

⁵¹ Cushny, A. R., *Pharmacology and Therapeutics*, 5th ed. Lea and Fe-biger, Philadelphia (1911) 497.

⁵² *Journ. Am. Wat. Works Ass.* No. 2, 22 (1930) 222.

CONCLUSIONS

Sodium and bicarbonic acid radicals are the predominating constituents of the artesian-well waters of Manila and vicinity.

The waters are soft and moderately mineralized. The few highly mineralized waters are located in Manila and Pasay south of Pasig River. Pasay is also characterized with moderately hard underground waters.

Seventy-two and one-half per cent of the waters contain sodium bicarbonate in concentration higher than the minimum that would exercise therapeutic action.

ILLUSTRATION

PLATE 1. Map showing the location of artesian wells in Manila and vicinity.

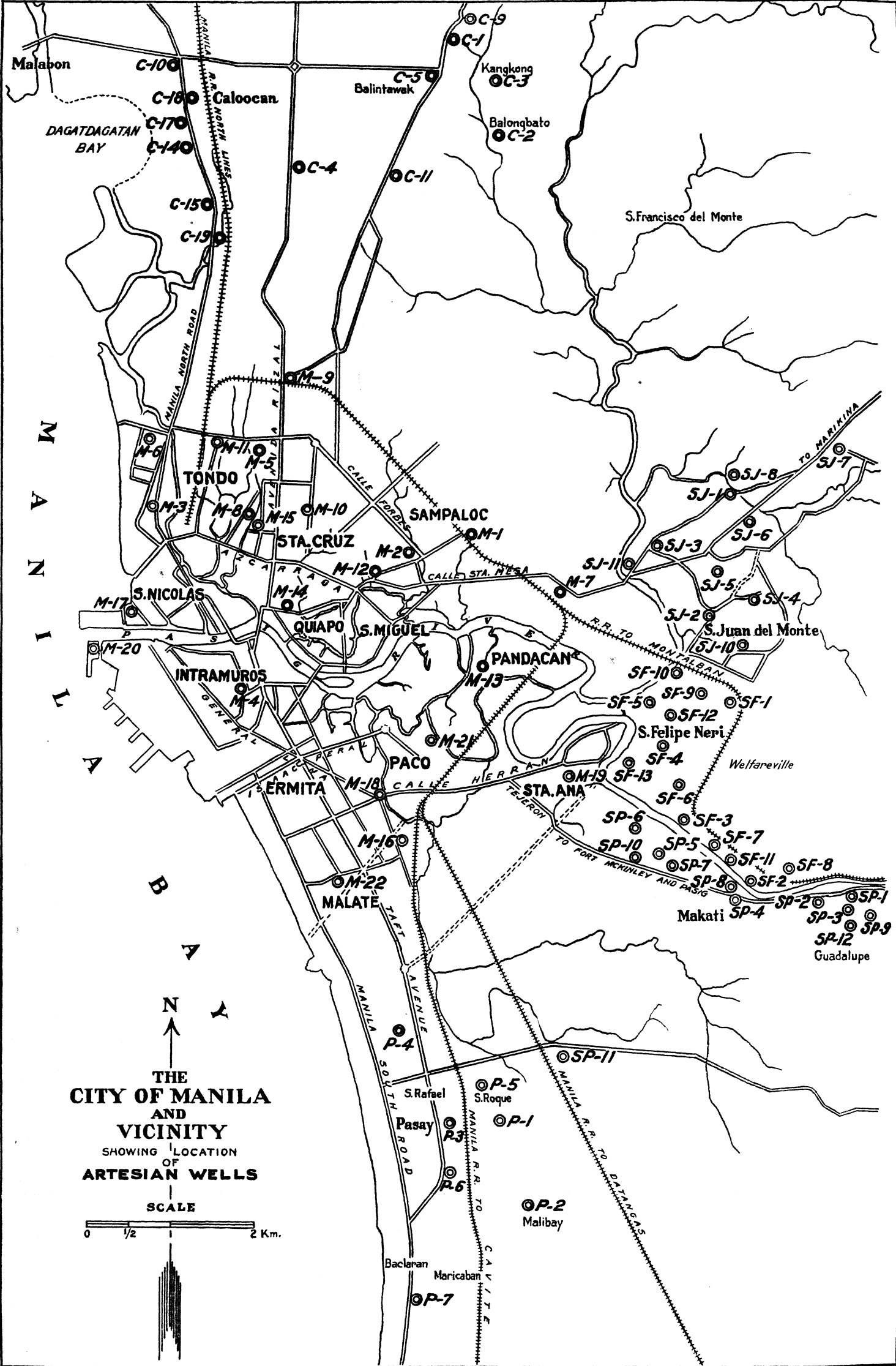


PLATE 1. THE CITY OF MANILA AND VICINITY, SHOWING THE LOCATION OF ARTESIAN WELLS.

RELATIVE RADIOACTIVITY OF DEEP-WELL WATERS IN MANILA AND VICINITY

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ONE TEXT FIGURE

Quite recently much interest has been created by radioactive waters. The main cause was the wide propaganda given various imported appliances used to impart radioactive properties to waters placed in contact with them, and the claim that the activated waters possessed curative properties. Taking advantage of this situation, local manufacturers of beverages began to advertise and sell natural radioactive bottled waters, taken from springs and deep wells. By inference, such waters were supposed to possess curative properties. From inquiries made by several persons at the Bureau of Science, it is apparent that this propaganda has created confused ideas in the public mind as to the true nature of radioactivity, resulting in the belief that it is one of the rarest properties of natural waters, and that all radioactive waters are medicinal.

In this connection the following quotations from the work of Collins¹ appear to be of interest.

Every natural water is more or less radioactive, and therefore the recognition of the presence of a small amount of radioactive material in any spring water does not set that water apart from other natural waters.

Knowledge of the presence of radioactive substances in waters is comparatively recent. Therefore, the radioactivity has been seized as something to talk about and advertise as a remarkable and unique property of many waters which are no more unique in their radioactivity than they are in their wetness.

To correct the wrong idea that has been impressed on the public mind regarding the nature and properties of radioactive waters and to obtain more information on the radioactivity of Philippine natural waters, this study was undertaken. It deals with the relative radioactivity of deep underground waters of the City of Manila and nearby municipalities.

¹ The Radioactivity of Natural Waters, Public Health Reports 41 (1926) 1937.

PREVIOUS WORK ON THE RADIOACTIVITY OF PHILIPPINE WATERS

The first quantitative determination of radioactivity of Philippine waters was made by Wright and Heise in 1916; several springs and some flowing wells were examined.² According to the authors, none showed an excessive amount compared with waters from other countries reported in the literature. In 1917, the waters of the mountainous regions of northern Luzon were also studied. A comparison of their radioactivity and that of the waters in the lowlands of Luzon indicated that the typical lowland waters have the higher radioactivity.³

COLLECTION OF SAMPLES AND METHODS OF PROCEDURE

All the artesian wells examined, with the exception of two, are pumping wells. The collection of samples from the pumping wells was made after continuous pumping for about twenty minutes. The glass-stoppered collecting bottle was completely filled with the water to prevent loss of activity in transit, through shaking or aëration. The radioactivity measurement was made within an hour after the collection of the sample.

The apparatus used is the "Fontaktoskop" of C. Engler and H. Sieveking.⁴ This apparatus, which for some time had been kept unused in the Bureau of Science, was recently readjusted and recalibrated at Braunschweig by Günther and Tegetmeyer.

The calibration tables for the apparatus give the equivalence in volts of the scale divisions on the electroscope. It was certified that the calibration measurements were made by means of a high-tension accumulator battery and referred to a Clark normal element that was tested by the "Physikalisch-Technischen Reichsanstalt." The apparatus is now working satisfactorily. The observed variation in the normal leak was from 10 to 25 volts per hour.

Although the method of procedure is based on the same general principle as the other methods usually followed by most experimenters, however, there are some differences in the details of the various phases of the measurement. The method⁵ is here-in briefly discussed.

² Philip. Journ. Sci. § A 12 (1917) 158.

³ Philip. Journ. Sci. § A 12 (1917) 293 and 309.

⁴ Ztschr. Anorg. Chem. 53 (1907) 1.

⁵ Given in the form of a pamphlet, with the calibration tables, by Günther and Tegetmeyer, of Braunschweig.

Measuring apparatus.—The Fontaktoskop consists of the following principal parts:

(a) Electroscope with base after Elster and Geitel modified in such a way that the leaflets are suspended.⁶ It is provided with microscope and scale.

(b) A tin container of 10 liters capacity, provided near the bottom with glass stopcock outlet.

(c) A dispersion cylinder with connecting shaft.

Measurement.—The actual measurement of radioactivity in waters may be divided into two main periods:

1. Driving off the emanation from the water, by shaking it with air in the tin container.

2. Determination of the electrical conductivity of the air in the vessel.

Order of procedure.—(a) Charge the electroscope; determine the normal leak, by reading on the scale the rate of downward fall in the tension of the leaflets, using a stop watch. The normal leak is caused by the presence of room air in the tin container.

(b) Remove the electroscope, pour in the water to be tested carefully and very slowly, letting it run on the inside walls of the container.

(c) Cover the mouth of the container with a tight fitting rubber stopper, and shake the water energetically for one-half minute.

(d) Place the container on a level surface, and allow sufficient time for the water to drain down from its sides.

(e) Open the stopcock outlet to release the excess pressure.

(f) Remove the rubber stopper, put the electroscope in its place, charge and note the rate of downward fall in the tension of the leaflets, in the same manner as in the determination of the normal leak.

Computation.—(a) The scale readings are now reduced to volts by means of the calibration tables, and recomputed on the basis of an hour and 1 liter.⁷

⁶ Zeitsch. für Elektrochemie 11 (1905) 715 and Zeitsch. für Anorg. Chemie 53 (1907) 5.

⁷ Sometimes, when the sample of water is highly radioactive, a smaller quantity is taken and shorter periods of measurement are adopted. Throughout this work, however, the quantity used was 1 liter and six readings were taken at 5-minute intervals.

(b) The normal leak recomputed on the basis of one hour is to be subtracted from these results.

(c) The found voltage is calculated in Mache units by means of the formula, $A = \frac{V}{300} \cdot \frac{C}{3,600} \cdot 1,000$,⁸ in which V = fall of potential in volts per hour, and C = capacity of the apparatus.

One Mache unit is considered in this work to be equivalent to $\frac{1}{2,670}$ microcurie, or in other words, one curie of emanation per liter, equals a concentration of 2,670 million Mache units.⁹

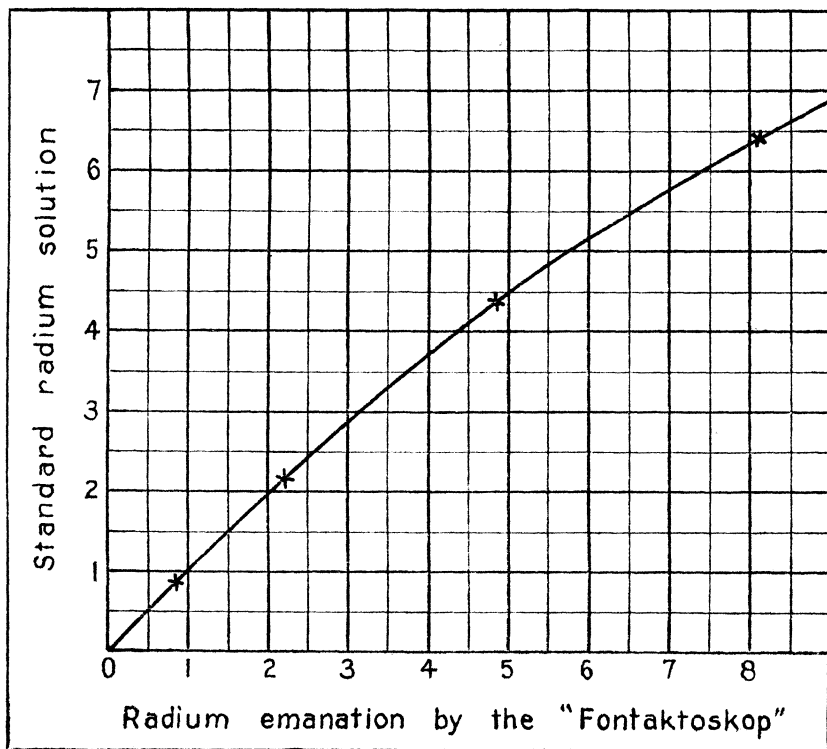


FIG. 1. Correction curve for the Fontaktoskop. Marginal figures are in Mache units.

In order to find how the results of tests would compare with solutions, prepared from a standard, containing known quantities of radium emanation, these solutions were tested by using the apparatus in the same manner as it had been used in testing water samples for radioactivity. The results show that for lower contents of radium emanation there is practically no dif-

⁸ Engler, C., H. Sieveking, and A. Koenig, Chem. Zeitg. 38 (1914) 425.

⁹ Sc. Am. Suppl. 2025 (1914) 260.

ference between the emanations found by measurement and the value of the standards, but for higher concentration, the results appear to differ from the standards in the manner shown by the curve in fig. 1. Accordingly this curve has been used to correct the results of the test.

RETESTS OF THE WATERS FROM SIBUL SPRINGS AND FROM A FLOWING WELL AT PARAÑAQUE

The waters of Sibul Springs, Bulacan, and of the flowing well at Parañaque, Rizal, which were considered by Heise¹⁰ to possess fairly constant radium-emanation content, have been retested by using the Fontaktoskop. The object was, primarily, to compare the results obtained by this method with those obtained by Wright and Heise¹¹ in 1916; and, secondarily, to get additional data on the constancy of the radioactivity of these spring and well waters. The agreement between the results of two determinations is very satisfactory, as shown in Table 1.

TABLE 1.—Comparative results of two different radioactivity measurements made in 1916 and in 1929.

Locality.	Radium emanation per liter. Grams $\times 10^{-12}$.	
	1916	1929
Flowing well, Parañaque, Rizal	632 (1.68 maches)	663 (1.77 maches).
Sibul Springs, San Miguel de Mayumo, Bulacan	1,284 (3.45 maches)	1,232 (3.29 maches).

The measurement of the water of the Parañaque well was made in situ, but that of the Sibul Springs water was made in Manila twenty-five hours after the water sample had been collected. The initial radium emanation was obtained by computation from the formula $I_0 = Ie^{at}$, using 0.00724 for the value of a ; t is the elapsed time in hours;¹² e , the base of the Napierian system of logarithm.

ORIGIN AND NATURE OF RADIOACTIVITY IN NATURAL WATERS

Boltwood,¹³ in a series of experiments, demonstrated that water can very readily acquire radioactive properties through brief contact with uranium minerals or with gaseous mixtures containing radium emanation. In the light of these experiments he explains the occurrence of radioactivity in natural waters as

¹⁰ Philip. Journ. Sci. § A 12 (1917) 310.

¹¹ Philip. Journ. Sci. § A 12 (1917) 145.

¹² Boltwood, B. B., Am. Journ. Sci. IV 18 (1904) 383.

¹³ Op. cit. 385-387.

due to extremely minute traces of uranium in the rocks and soils through which these waters percolate in their underground passage.

From the above observation and from our knowledge of the properties of radioactive substances, it is apparent that underground waters acquire their radioactivity either by absorbing the radioactive gases, which are constantly thrown off by minute quantities of radioactive minerals distributed in the bosom of the earth, or by decomposing and dissolving small quantities of these minerals.

The activity due to dissolved gases is necessarily of a temporary nature, because as soon as the water is removed from its source, its activity begins to diminish, falling to one-half of its original value¹⁴ in about 3.9 days. The activity due to dissolved radioactive minerals is of a permanent nature, because the supply of emanation is being constantly renewed by the decomposition of the active minerals.

Studies made by various authors indicate that the radium emanation encountered in a great proportion of natural waters is practically all due to radioactive gases that have diffused into them, rather than to radium salts in solution. Such have been the experiences of Schmidt and Moore,¹⁵ in studying the radioactivity of the thermal waters of Yellowstone National Park; of Wright and Heise,¹⁶ in their study of the radioactivity of Philippine waters; of Satterly and Elworthy,¹⁷ in their investigations of the mineral springs of Canada; and of T. F. Buehrer, in his study of the radioactivity of the thermal waters of Castle Hot Springs, Arizona.¹⁸

One of the most radioactive waters known in the world is the Quelle am Schweitzergang at Joachimsthal, Bohemia.¹⁹ The radium emanation content of the water is approximately 70,000 units per liter (187 Mache units per liter). In the neighborhood of the spring, the pitchblende that has been the chief European source of radium is mined. More highly radioactive than this, however, is one of the hot-spring waters in Arkansas. According to Deaderich, an investigation made by Professor Boltwood, of Yale University, in 1904 showed this spring water to contain

¹⁴ Boltwood, B. B., *Am. Journ. Sci.* IV 20 (1905) 128-132.

¹⁵ U. S. Geol. Surv. Bull. 395 (1909) 30.

¹⁶ Philip. Journ. Sci. § A 12 (1917) 158.

¹⁷ Canadian Dept. of Mines, Mines Branch, Bull. 16 (1917) 6.

¹⁸ *Am. Journ. Sci.* 213 (1927) 447-448.

¹⁹ Canadian Dept. of Mines Bull. 16 (1917) 47.

an activity of 265.6 Mache units.²⁰ In the Philippine Islands, the most highly radioactive water encountered by Wright and Heise is the water from artesian well 686 of the Municipality of Batangas, Batangas. Its emanation content is equivalent to $2,100 \times 10^{-12}$ grams of radium per liter²¹ (5.6 Mache units per liter).

A more highly radioactive water than this, however, is the water from SP-1, located in San Pedro Makati, Rizal. Its radium emanation content is equivalent to 5.94 maches ($2,225 \times 10^{-12}$).

Few waters containing relatively higher quantities of radium salts in solution have been reported. Among those showing the highest activity due to dissolved radioactive minerals are: (a) The waters from Kings Well at Bath, England, containing 0.1387 milligram radium per million liters²² (0.37 Mache unit per liter); (b) the waters from Hawthorne 2, Saratoga Springs, New York, containing 99×10^{-12} grams of radium per liter²³ (0.264 Mache unit per liter); and (c) the waters from Fairmount Springs, British Columbia, containing 0.1 millionth of a milligram of radium per liter²⁴ (0.267 Mache unit per liter). In the Philippine Islands, none of the springs or deep wells examined in previous work or in this work has been found to contain more than traces of radioactivity due to radioactive minerals in solution.

THERAPEUTIC PROPERTIES OF RADIOACTIVE WATERS

Since the appearance on the local market of "radium ore jars," the inner walls of which are lined with radioactive minerals, for the purpose of imparting larger quantities of radioactivity to waters placed within, all kinds of literature and advertisements on radioactivity have been published and liberally distributed in the city and in the provinces. It was naturally to be expected that these publications would contain only opinions in favor of the use of radioactive waters in the treatment of human illness, but such a one-sided way of presenting the subject may lead to wrong interpretations on the part of the public, in regard to the usefulness and true health value of radioactive waters.

²⁰ New York Med. Journ. 103 (1916) 550.

²¹ Philip. Journ. Sci. § A 12 (1917) 163.

²² Sir William Ramsay, Chem. News 105 (1912) 134.

²³ Moore and Whittemore, Journ. Ind. Eng. Chem. 6 (1914) 552.

²⁴ Boyle and McIntosh, Trans. Roy. Soc. Canada § III 7 (1913) 163.

The present status of the therapeutic value of radioactive waters, judging from the works of various authors, appears to be quite indefinite; that is, it is still under study and observation. Burham,²⁵ in his studies on the value of radioactive waters in the treatment of gout, came to the conclusion that the action is in many cases, if not in every case, a favorable one. Lautman,²⁶ writing of the physiological action of the natural radioactive waters of Hot Springs, Arkansas, stated that these waters may be considered to produce a beneficial effect in the treatment of rheumatism, gout, chronic arthritis, neuralgia, nephritis, chronic skin diseases, etc., but are of no value in any form of tuberculosis and malignant neoplasms. He added, however, in his concluding remarks, that there are always skeptical persons who would maintain that the change and the rest account for the remarkable improvements and cures that are clinically observed at hot springs. Field,²⁷ in January, 1926, wrote an article on radium therapy, and in his reference to the use of radioactive waters for certain types of faulty elimination, he says that 90 per cent of the reported cases were favorable, and yet the amount of energy supplied by such waters was comparatively small. One year later another article on the same subject appeared.²⁸ According to this article, the "sipping cure" method, or application of radium emanation by inhalation or by drinking activated waters, has not been effective and it has consequently dropped into disuse; in its place, the intravenous administration of soluble salts of radium has been adopted. Even with this method, the results have been meager, transient or entirely negative; hence the following concluding statement: "Radium treatment is rarely now employed in our wards in spite of the fact that it always can be had on request."

RESULTS

The radium-emanation content of the different well waters examined is shown in Table 2. The depths of the wells, capacity, temperatures, and total mineralization of the waters are also included in the table to facilitate the study of any relation that may exist between these properties and their radioactivity.

²⁵ Med. Rec. 81 (1912) 117-119.

²⁶ Southwestern Med. 8 (1924) 435-437.

²⁷ Am. Med. 32 (1926) 40.

²⁸ Allen, E. V., H. H. Bowing, and L. G. Rowntree, Journ. Am. Med. Assoc. 88 (January, 1927) 164.

For every municipality the data are arranged in ascending order in relation to the total mineral content of the waters.

GENERAL CONSIDERATION OF THE RESULTS

No abnormal quantities of radioactivity have been encountered in the artesian-well waters examined. The radium emanation of 5.62 maches, the highest reported by Wright and Heise in 1916,²⁹ and 5.94 maches, the highest encountered in this work, are too low compared with the dose considered to be medicinal.

Compared with the waters of the famous springs of Europe and America, the quantities found would also appear very little. The Quelle Am. Schweitzergang, at Joachimsthal, Austria, has 186.8 maches (70,000 units). The Choussy Spring, La Bourboule, France, has 61.2 maches (22,900 units). The Lambinet Spring, Plombières, has 42.4 maches (15,900 units); and the Imperial Spring, Hot Springs, Arkansas, has 26.9 maches (10,000 units).³⁰

The Sibul Springs water, widely known in the Philippine Islands as medicinal water, according to the results of tests possesses about as much radioactivity as the waters from the following wells: In Manila, the wells located at Santiago Street, near G. Tuason, at Plaza Guipit, and at Plaza Miranda, near the Quiapo Church; in Caloocan, the wells located at the municipal plaza and at A. Mabini Street, near kilometer 7; and in San Pedro Makati, the well located at the corner of José Rizal and P. P. Roxas Streets.

RELATION BETWEEN RADIOACTIVITY AND OTHER PROPERTIES

The quantity of emanation seems to bear no general relation to the commonest physical and chemical properties of the waters. Differences in depths, rates of flow, temperatures, and total mineralization of the water, as a whole, appear to be independent of the differences in radioactivity. Schlundt and Moore³¹ have pointed out that no detectible difference in activity exists between acid and alkaline waters, Wright and Heise³² found no general relations between the chemical quality of a water and its radioactivity, and Satterly and Elworthy³³ believe that fresh-

²⁹ Philip. Journ. Sci. § A 12 (1917) 145.

³⁰ Canadian Dept. of Mines Bull. 16 (1917) 46.

³¹ U. S. Geol. Surv. Bull. 395 (1909) 30.

³² Philip. Journ. Sci. § A 12 (1917) 159.

³³ Canadian Dept. of Mines Bull. 16 (1917) 48.

TABLE 2.—Radioactivity of artesian-well waters of Manila and vicinity.

Tracing No.	Location.	Depth of well.	Date of collection of sample.	Capacity of well; liters per minute.	Temperature, °C.		Total mineralization, in parts per million.	Radium emanation, in Mäcbe units per liter.
					Water.	Air.		
	MANILA.	Meters.	1929					
M-1	Santiago, near G. Tuason, Sampaloc	160	July 23	29	30.4	27.5	215	3.01
2	Plaza Guipit, Sampaloc	-----	Sept. 11	31	30.5	29.4	250	3.89
3	Plaza Moriones, Tondo	260	May 29	30	33	29.4	260	2.05
4	Corner Muralla and Victoria Streets, Intramuros	223	May 20	30	31.5	30.9	275	1.64
5	San Lazaro Hospital	269	July 13	-----	30.5	29.5	295	2.06
6	Esguerra, between Yangco and Franco Streets, Tondo	119	July 22	35	30.1	30.1	305	1.95
7	Santa Mesa Market, at Teresa Street	170	July 11	24	30.6	29.8	315	2.14
8	Estado, between Benavidez and Magdalena	-----	June 8	8	31.5	29.7	350	0.58
9	San Lazaro market, at Blumentritt Street	129	June 27	33	29.5	29.2	350	1.86
10	Santa Clara School, Andalucia Street	136	July 18	27	29.5	28.4	370	1.82
11	Antonio Rivera, near Tayuman	122	July 20	34	30.1	29.4	370	1.10
12	Manrique, in front of Sampaloc Church	136	June 11	26	29.5	33	375	2.08
13	Jesus and Narciso, Pandacan	144	June 25	34	30.2	32.1	395	0.76
14	Plaza Miranda, near Quiapo Church	153	June 4	34	30.2	28.6	485	3.75
15	O'Donnell, between Lope de Vega and Zurbaran	118	July 6	29	29.6	27.5	545	1.80
16	Anak Bayan, Paco	154	July 9	33	30.5	25.6	545	2.40
17	Del Pan, San Nicolas	92	July 19	45	30.2	29.1	595	1.77
18	Paco Market, Dart and Herran Streets	101	June 21	36	29.5	30.7	625	1.87
19	Santa Ana Market, Calderon Street	166	June 11	28	30.2	29.6	755	1.93
20	Engineer Island	178	Oct. 8	-----	-----	-----	880	0.91
21	Plaza de la Virgen, Pandacan	205	Aug. 12	30	29.3	28.4	965	2.40
22	Malate Market, at Leveriza	198	May 17	34	31.1	32.4	1,145	1.82

CALOOCAN

C-1	Novaliches Road, between kms 10 and 11.	150	Sept. 19	30	28.5	27.9	180	1.67
2	Balon Pato, Novaliches Road, between kms 9 and 10.	107	Sept. 24	32	29.2	28.3	180	2.22
3	Cangcong Barrio, Novaliches Road, between kms 8 and 9.	107	Sept. 27	63	28.6	28.5	215	0.80
4	Rizal Avenue extension, between kms 6 and 7.	151	July 3	30	29.8	29.6	220	1.38
5	Balintawak, near km 9	126	Oct. 1	39	29.6	28.8	225	2.21
6	Novaliches Road, between kms 17 and 18.	107	June 18	34	28.6	35.0	235	1.77
7	Novaliches Plaza, between kms 17 and 18	102	Aug. 3	28	28.3	25.4	235	1.38
8	San Bartolome, Novaliches Road, between kms 16 and 17.	100	Aug. 8	26	27.7	26.1	270	1.60
9	Baisa Barrio, Balintawak, between kms 12 and 13.	107	Aug. 29	31	28.1	23.6	270	2.28
10	Mabini, near Saigandaan.	123	June 6	34	29.7	31.9	275	0.95
11	Dulong Calzada, between kms 8 and 9.	145	July 25	27	29.7	26	275	1.67
12	Baisa Barrio, Balintawak, between kms 11 and 12.		Sept. 5	18	28.9	30.3	280	1.86
13	Novaliches Road, between kms 14 and 15.	84	Aug. 20	25	28.0	26.5	300	1.12
14	A. Mabini, between kms 8 and 9.	124	Aug. 27	29	29.2	29.5	310	1.49
15	Sampalucan, Mabini, between kms 7 and 8.	191	July 16	30	31	28.4	320	0.58
16	Talipapa, Balintawak, between kms 13 and 14.	116	Aug. 24	27	29.2	26.1	330	0.68
17	Caloocan Plaza, at municipal building.	218	Sept. 17	50	30.4	27.5	330	3.06
18	A. Mabini, North Road, near km 9.	205	Sept. 23	13	31.2	29	330	1.56
19	A. Mabini, North Road, near km 7.	84	Oct. 3	37	28.5	25.2	335	3.75
SAN JUAN DEL MONTE.								
SJ-1	Mariquina Road, between kms 7 and 8.	157	Sept. 20	29	30.1	31.2	245	2.30
2	Corner Blumentritt and Bonifacio.		Aug. 23	8	29.5	29.5	290	1.45
3	Market place.	101	May 23	21	29.5	31.1	295	0.40
4	Santa Lucia Barrio.	72	July 31	27	29.7	29.5	235	2.69
5	Rizal Street, near Burgos.		Sept. 9	30	30.2	29.3	295	1.10
6	Ermitaño Barrio, East Street.	55	Oct. 4	49	30	29.4	295	1.66
7	Mariquina Road, between kms 8 and 9.		July 2	34	29	30.4	300	1.32
8	Broadway, near First Street, New Manila.		Sept. 23	14	29.5	32.3	300	1.77
9	Cubao Barrio, Mariquina Road, between kms 10 and 11.	150	Sept. 13	31	28.5	29.0	305	1.77
10	Ortega Street, San Juan Heights addition.	93	Aug. 2	36	30	28	320	1.82
11	San Pedro, Mariquina Road, near km 6.	93	Oct. 2	33	28.4	29.9	390	2.80

TABLE 2.—Radioactivity of artesian-well waters of Manila and vicinity.—Continued.

Tracing No.	Location.	Depth of well.	Date of collection of sample.	Capacity of well, liters per minute.	Temperature, °C.		Total mineralization, in parts per millions.	Radium emanation, in Maché units per liter.
					Water.	Air.		
Meters.								
SAN FELIPE NERI.								
SF-1	Hagdaan Bato, Bonifacio Street.	120	Oct. 8	34	29.7	25.2	275	0.91
2	T. Kalazan, near river	47	Sept. 26	38	28.7	28.9	295	2.23
3	Lamayán, corner Rizal and Vergara	110	Oct. 1	35	29.6	29.6	300	0.84
4	Blumentritt, between municipal building and school	63	Aug. 1	23	28.7	27.5	305	1.98
5	Mabini Street	126	Sept. 10	28	29.8	29.6	305	2.74
6	Zanaga Barrio	96	Aug. 6	38	29.1	26.8	310	0.85
7	Jolo Barrio	90	Aug. 19	26	29.2	28.1	310	2.30
8	Barranca	109	Sept. 14	30	28.6	30.5	315	1.06
9	Hagdaan Bato, corner A. Luna and Bonifacio	60	Aug. 21	27	29.0	29.0	325	0.98
10	Kalentong Street, between kms 9 and 10.	46	Sept. 7	31	28.6	26.7	335	1.40
11	Jolo Barrio, at J. Coronado	106	Aug. 23	33	29.5	29.6	345	1.88
12	Blumentritt, in front of market	270	July 30	24	30.8	29.1	495	2.38
13	Lamayán Barrio, Segura and Rizal Streets	130	Sept. 25	33	29.6	30.5	635	2.14
SAN PEDRO MAKATI.								
SP-1	Guadalupe, McKinley Road, between kms 7 and 8	129	Aug. 7	34	29.5	27.2	225	5.94
2	McKinley Road, between kms 6 and 7	108	July 27	33	29.9	28	230	2.51
3	Guadalupe, Ninety-sixth Street	84	Aug. 22	18	30	30.2	280	2.61
4	Jose Rizal and P. P. Roxas	171	June 29	31	30.1	30.2	285	3.12
5	Olimpia Barrio, J. B. Roxas	129	Sept. 26	17	30.2	32.6	300	2.09
6	Bonifacio Street, 1 km east of municipal building	104	Oct. 3	36	28.8	25.2	305	2.12
7	E. Zobel Street	124	Oct. 7	30	28.9	28.5	360	0.54
8	Cristal Barrio, in front of chapel	220	Oct. 5	36	31.3	29.1	365	2.79

9	Masilang Barrio, Soliman, near Comercio	128	Oct. 24	28	31.3	29.1	390	1.02
10	Tejeron Barrio, McKinley Road, between kms 4 and 5	109	Sept. 18	32	29.5	33	410	2.20
11	Culiculi Barrio, near Batangas railroad	55	Aug. 10	33	29	27.1	415	1.33
12	Guadalupe, in front of Dapitan Street	130	Sept. 6	22	30.3	28.2	420	1.66
PASAY.								
P-1	San Roque Barrio, corner Tolentino and Protacio	69	Aug. 30	31	28.4	26.8	415	4.63
2	Malibay Barrio, San Jose Street, near chapel	149	Aug. 26	29	30.2	30.5	425	1.79
3	Santol Barrio, corner Protacio and Decena	179	Sept. 12	29	32.2	31.5	535	1.42
4	Leviza, near Villaruel		July 29	29	31.0	29.3	585	2.57
5	Corner Tolentino and Aurora	108	Aug. 5	35	29.5	26.4	730	1.78
6	Corner Zamora and Apelo Cruz, Tabon Barrio	92	July 26	33	28.7	25.4	935	1.97
7	Tambo Barrio, at Camp Claudio		May 18	37	30.7	31.5	1,245	1.44

water springs are nearly always more temporarily radioactive than mineralized waters. Although none of the waters examined may be considered as highly mineralized as the spring water reported by Satterly and Elworthy, nevertheless, it has been observed that in the municipalities of San Pedro Makati and Pasay, the waters having a lower content of total mineral matter are relatively more radioactive than the more-mineralized waters. This generalization, however, is not applicable to the rest of the well waters.

THERAPEUTIC VALUE

According to Collins,³⁴ the radioactivity should be between 20 and 500 millimicrocuries per liter (53.4 to 1,334 maches) in order to be considered at all as a factor in the use of water as medicine. On the basis of this statement it is evident that none of the waters examined may be considered medicinal because of radium emanation content.

The general results, however, show that the quantity of radioactivity compares very favorably with that found in a large proportion of natural waters in other parts of the world. A resumé of radioactive measurements made by different authors appears in the same article of Collins, as follows; 72 per cent of 422 spring waters in Germany gave radioactivity of less than 2.5 millimicrocuries (6.67 maches) per liter, 14 waters at Saratoga Springs, New York, were measured and found to contain 0.039 to 0.88 millimicrocurie per liter (0.1 to 2.34 maches), 23 well waters and 47 spring waters in Canada gave 0.0014 to 0.176 millimicrocurie (0.003 to 0.47 mache) and 0.0112 to 0.64 millimicrocurie (0.03 to 1.70 maches), respectively. Eighty-five per cent of 178 mineral waters in Colorado gave less than 2.5 millimicrocuries (6.67 maches). In this work the minimum radioactivity encountered is equivalent to 0.40 mache (SJ-3) and the maximum is 5.94 maches (SP-1). Although none of the waters gave a higher radioactivity than 5.94 maches, it is safe to assume that many of these waters possess as much radioactivity as some of the waters from the well-known Saratoga and Colorado springs.

³⁴ U. S. Pub. Health Reports 41, No. 37 (1926) 1937.

CONCLUSIONS

There is no wide variation in the radioactivity of the waters examined.

Although no abnormal quantities of radium emanation have been encountered, the general results compare very favorably with the average results obtained in other parts of the world.

As has been found true of a large proportion of natural waters elsewhere, the radium-emanation content of these waters is far below the minimum quantity that those who have studied the subject consider necessary to produce any therapeutic effect.

ILLUSTRATION

TEXT FIG. 1. Correction curve for the Fontaktoskop. Marginal figures are in Mache units.

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BACTERIOLOGICAL SURVEY OF ARTESIAN WELLS IN MANILA AND VICINITY

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The regulation of the Philippine Health Service requires that all newly constructed artesian wells must be examined bacteriologically and the findings must conform with the requirements of the standard for drinking waters before the wells are opened to the public. The artesian wells that are in use by the public are examined bacteriologically from time to time at the discretion and request of the Philippine Health Service. The standard for untreated drinking waters in the Philippines is that the water must not contain more than 500 colonies per 1 cubic centimeter and the test for *Bacillus coli* must be negative. The standard for treated waters is that the water must not contain more than 100 colonies per 1 cubic centimeter and the *B. coli* test must be negative.

In connection with a survey made for the purpose of ascertaining the chemical quality of the artesian well waters, a bacteriological survey of these wells was made simultaneously. Only one bacteriological examination of each well was performed. The examination, however, was performed at random; therefore, it gives an account of the conditions prevailing in these artesian wells at that time.

The bacteriologic examination of the artesian wells concerned was carried out in two directions. 1. The total number of colonies per 1 cubic centimeter of the water was ascertained. 2. Search was made for faecal contamination. This was done in two ways. Search was made for presence of *B. coli* and for choleralike vibrios.

COLLECTING OF SAMPLES

The samples were collected by the bacteriologist of the Bureau of Science, in person, in such a way that the water was pumped for about ten minutes before the sample was taken. The samples were collected in wide-mouthed, cotton-stoppered, sterilized, 200

cubic-centimeter bottles. The examination was performed immediately upon arrival at the laboratory.

COLONY COUNT

For this purpose agar plates were used. By means of sterilized graduated pipettes, 0.1 and 0.5 cubic centimeter of water was placed at the bottom of a sterile Petri dish. Melted agar that had been kept at 40° C. was poured into the Petri dish and thoroughly mixed with the water by inclining the dish. Incubation at 37° C. for forty-eight hours followed. Colonies were counted at the end of forty-eight hours incubation and an average number of colonies per 1 cubic centimeter was calculated.

TEST FOR *B. COLI*

By means of sterile pipettes, 1 cubic centimeter and 10 cubic centimeters, respectively, of each particular sample of water was placed in Smith fermentation tubes containing lactose bouillon. The Smith tubes were incubated for forty-eight hours and if they showed gas production, further search for *B. coli* was made. This part of the procedure just mentioned is referred to in the table as presumptive test for *B. coli*. The verification of presence of *B. coli* in the fermentation tubes that showed gas production was carried out by planting several loopfuls of the bouillon on the surface of an eosin-methylene blue-lactose agar plate. After twenty-four hours incubation, the colonies were examined. Colonies showing dark discolorization and metallic luster were transplanted for further identification.

TEST FOR VIBRIOS

After the necessary amounts were taken for the colony count and *B. coli* test the remainder of each sample of water was enriched by adding an equal amount of cholera peptone. After twenty hours incubation several loopfuls of the water peptone mixture were planted on the surface of Dieudonne-alkaline blood agar-plates. The colonies that developed during twenty-four hours incubation of the plates were examined to determine whether or not they consisted of vibrios. Hanging drop, smears stained with diluted fuchsin, and serum agglutination tests were made.

DISCUSSION

From Table 1 it is evident that of seventy-two artesian wells examined only three were found to contain more colonies per 1 cubic centimeter than is permitted by the standard. Two of

these three artesian wells contained more than 900 colonies per 1 cubic centimeter, and one exceeded slightly the number of colonies allowed by the standard. All the rest of them came within the standard requirements with regard to the number of colonies per 1 cubic centimeter. Samples from eight wells exceeded 100 colonies per 1 cubic centimeter but had less than 200 colonies per 1 cubic centimeter, while the rest showed less than 100 colonies per 1 cubic centimeter.

With regard to the presumptive test for *B. coli*, five wells gave positive gas formation in amounts of 10 cubic centimeters of the water, while ten wells gave positive gas production in 1 cubic centimeter and 10 cubic-centimeter amounts.

Confirmatory test for *B. coli* was negative in all samples of water.

The test for choleralike vibrios showed that seven of the wells were positive at the time of the test.

THE SIGNIFICANCE OF FINDINGS

The colony count is usually taken as an indication of the number of bacteria per cubic centimeter of the tested water. This manner of estimation is only approximate since one colony does not necessarily originate from one bacterium. It may happen that a clump of bacteria will give rise to one colony. However, the number of colonies encountered on plates is a fair indication of the bacterial content of the water. In this respect, the fact must be kept in mind that the bacterial content will increase rapidly on storage under ordinary room temperature. The factors responsible for the rate of multiplication of bacteria upon storage are the initial number of bacteria in the water; the amount of suspended or dissolved mineral, but particularly organic substances; and the temperature. In the Tropics the temperature naturally is more favorable throughout the year for the multiplication of bacteria in water than it is in cold countries. The examination concerning colony counts should be made, therefore, as soon as possible after the sample of water has been taken. If the initial bacterial count of a given water is very low, the examination may still give satisfactory results when performed two hours after taking the sample. The multiplication of bacteria in the water goes on by geometric progression, and the curve which is plotted out of the colony count performed at intervals of time naturally rises rapidly at room temperature after twelve hours storage. Treated waters show considerable inhibition of bacterial multiplication

TABLE 1.—Results of bacteriologic examinations of artesian water from wells in Manila and vicinity.

Tracing No.	Location.	Well No.	Date of collection of samples.	Num-ber of colonies per cc.	Presumptive test.		<i>B. coli</i> .	Cholera-like vibrios.
					1 cc.	10 cc.		
MANILA.								
M-1	Santiago, near G. Tuason, Sampaloc	1921	1929	5	-	-	-	Negative.
2	Plaza Guipit, Sampaloc.		July 23	167	+	+	-	Do.
3	Plaza Moriones, Tondo.		Sept. 11	10	-	-	-	Do.
4	Corner Muralla and Victoria Streets, Intramuros	1939	May 29	10	-	-	-	-
5	San Lazaro Hospital.	1528	May 20	4	-	-	-	-
6	Esguerra, between Yangco and Franco Streets, Tondo.	1929	July 13	56	-	-	-	Negative.
7	Santa Mesa Market, at Teresa Street	1505	July 11	7	-	-	-	Do.
8	Estado Street, between Benavidez and Magdalena	1456	June 8	15	-	+	-	Do.
9	San Lazaro market, at Blumentritt Street	1479	June 27	100	-	-	-	Do.
10	Santa Clara School, Andalucia Street.	1629	July 18	35	-	-	-	Do.
11	Antonio Rivera, near Tayuman.	1674	July 20	22	-	-	-	Do.
12	Manrique Street, in front of Sampaloc Church	1665	June 13	40	-	-	-	Do.
13	Jesus and Narciso Streets, Pandacan	1433	June 25	400	-	-	-	Do.
14	Plaza Miranda, at Quiapo Church	1446	June 4	60	-	-	-	Do.
15	O'Donnell, between Lope de Vega and Zarburan	1689	July 6	30	-	+	-	Do.
16	Anak Bayan, Paco.	1599	July 9	3	-	-	-	Do.
17	Del Pan, San Nicolas.	1630	July 19	5	-	-	-	Do.
18	Paco Market, Dart and Herran Streets	1675	June 21	4	-	-	-	Do.
19	Santa Ana Market, Calderon Street	1396	June 11	70	-	-	-	Do.
20	Engineer Island.	1	Oct. 8	972	-	+	-	Do.
21	Plaza de la Virgen, Pandacan.	2425	Aug. 12	32	-	-	-	Positive.
22	Malate Market, at Leveriza Street	1658	May 17	50	-	+	-	Negative.

CALOOCAN.

C 1	Novaliches Road, between kms 10 and 11	Sept. 19	5	—	—	Do.
2	Balon bato, Novaliches Road, between kms 9 and 10	2487 Sept. 24	7	—	—	Do.
3	Cangcong Barrio, Novaliches Road, between kms 8 and 9	2576 Sept. 27	19	—	—	Do.
4	Rizal Avenue extension, between kms 6 and 7	1916 July 3	5	—	—	Do.
5	Balintawak, near km 9	895 Oct. 1	10	—	—	Do.
6	Novaliches Road, between kms 17 and 18	2505 June 18	40	—	—	Do.
7	Novaliches Plaza, between kms 17 and 18	916 Aug. 3	11	—	—	Do.
8	San Bartolome, Novaliches Road, between kms 16 and 17	925 Aug. 8	53	+	—	Do.
9	Baisa Barrio, Balintawak, between kms 12 and 13	950 Aug. 29	12	—	—	Do.
10	Mabini Street, near Saigandaan	1472 June 6	5	—	—	Do.
11	Dulong Calzada, between kms 8 and 9	1867 July 25	16	—	—	Do.
12	Baisa Barrio, Balintawak, between kms 11 and 12	Sept. 5	130	+	—	Do.
13	Novaliches Road, between kms 14 and 15	938 Aug. 20	130	—	—	Do.
14	A. Mabini, between kms 8 and 9	2478 Aug. 27	1	—	—	Do.
15	Sampalucan, A. Mabini, between kms 7 and 8	695 July 16	152	+	—	Do.
16	Talipapa, Balintawak, between kms 13 and 14	2571 Aug. 24	24	—	—	Do.
17	Caloocan Plaza, near municipal building	105 Sept. 17	30	—	—	Positive.
18	A. Mabini, Manila North Road, near km 9	683 Sept. 28	1	—	—	Negative.
19	A. Mabini, Manila North Road, near km 7	2469 Oct. 3	35	—	—	Do.

SAN JUAN DEL MONTE

SJ-1	Mariquina Road, between kms 7 and 8	2354 Sept. 20	18	—	—	Do.
2	Corner Blumentritt and Bonifacio	Aug. 28	920	+	—	Do.
3	Market place	878 May 23	50	—	—	Do.
4	Santa Lucia Barrio	1806 July 31	105	+	—	Do.
5	Rizal Street, near Burgos	Sept. 9	3	—	—	Do.
6	Ermifaño Barrio, East Street	1744 Oct. 4	3	—	—	Do.
7	Mariquina Road, Ermitaño Barrio, between kms 8 and 9	July 2	10	—	—	Do.
8	Broadway, near First Street, New Manila	Sept. 23	6	—	—	Do.
9	Cubao Barrio, Mariquina Road, between kms 10 and 11	1812 Sept. 13	5	+	—	Do.
10	Ortega Street addition	2334 Aug. 2	10	—	—	Do.
11	San Pedro Street, near km 6, Mariquina Road	1780 Oct. 2	32	—	—	Do.

TABLE 1.—Results of bacteriologic examinations of artesian water from wells in Manila and vicinity—Continued

Tracing No.	Location.	Well No.	Date of col-lection of samples.	Num-ber of colonies per cc.	Presumptive test.		B. coli.	Choleralike vibrios.
					1 cc.	10 cc.		
SAN FELIPE NERI.								
SF-1	Hagdaan Bato, Bonifacio Street.....	2535	1929 Oct. 8	83	—	—	—	Positive.
2	T. Kalazan, near river.....	1636	Sept. 26	1	—	—	—	Negative.
3	Lamayan, corner Rizal and Vergara.....	872	Oct. 1	7	—	—	—	Do.
4	Blumentritt, between municipal building and school.....	859	Aug. 1	3	—	—	—	Do.
5	Mabini Street.....	1840	Sept. 10	43	—	—	—	Do.
6	Zanaga Barrio.....	2527	Aug. 6	16	—	—	—	Do.
7	Jolo Barrio.....	2375	Aug. 19	590	—	—	—	Do.
8	Barranca.....	1664	Sept. 14	8	—	—	—	Do.
9	Hagdaan Bato, corner A. Luna and Bonifacio.....	863	Aug. 21	341	—	—	—	Do.
10	Kalentong Street, between kms 9 and 10.....	1832	Sept. 7	14	+	+	—	Do.
11	Jolo Barrio, at J. Coronado.....	1712	Aug. 23	9	+	+	—	Do.
12	Blumentritt, in front of market.....	798	July 30	5	—	—	—	Do.
13	Lamayan Barrio, Segura and Rizal Streets.....	2520	Sept. 25	6	—	—	—	Do.
SAN PEDRO MAKATI.								
SP-1	Guadalupe, McKinley Road, between kms 7 and 8.....	1610	Aug. 7	4	—	—	—	Do.
2	McKinley Road, between kms 6 and 7.....	802	July 27	9	—	—	—	Do.
3	Guadalupe, 96 Street.....	1622	Aug. 22	3	—	—	—	Do.
4	Jose Rizal and P. P. Roxas.....	258	June 29	120	—	—	—	Do.
5	Olimpia Barrio, J. B. Roxas Street.....	786	Sept. 26	5	—	—	—	Do.
6	Bonifacio Street, 1 km east of municipal building.....	2052	Oct. 3	129	—	—	—	Do.
7	E. Zobel Street.....	814	Oct. 7	115	+	+	—	Positive.
8	Cristal Barrio, in front of chapel.....	1995	Oct. 5	12	—	—	—	Negative.
9	Masilang Barrio, Soliman, near Comercio.....	841	Sept. 24	13	—	—	—	Do.

10	Tejeron Barrio, McKinley Road, between kms 4 and 5.....	2013	Sept. 18	46	—	—	Do.
11	Culiculi Barrio, near Batangas railroad track.....	1445	Aug. 10	35	+	—	Do.
12	Guadalupe, in front of Dapitan Street.....	1601	Sept. 6	2	—	—	Do.
PASAY.							
P-1	San Roque Barrio, corner Tolentino and Protacio.....	732	Aug. 30	3	—	—	Do.
2	Malibay Barrio, C. José Street, near chapel.....	877	Aug. 26	1	—	—	Do.
3	Santol Barrio, corner Protacio and Decena.....	765	Sept. 12	13	+	—	Positive.
4	Leveriza, near Villaruel.....		July 29	9	—	—	Negative.
5	Corner Tolentino and Aurora.....	768	Aug. 5	2	—	—	Do.
6	Zamora Street, corner Apelo Cruz, Tabon.....	444	July 26	23	—	—	Positive.
7	Tambo Barrio, at Camp Claudio.....		May 18	50	—	—	Do.

as long as the disinfectant is still present in the stored water. After the chlorine, for instance, has disappeared from a sample of water, the bacteria multiply rapidly.

The presumptive test is used as a preliminary test and as an indication of whether or not a further search for *B. coli* should be attempted. A positive presumptive test indicates that some sugar fermenters are present. *Bacillus coli* is only one of the many bacteria that ferment sugars. Consequently, not much significance should be attributed to this test, particularly when the colony count is low and the bacteria responsible for the fermentation are of the *aerogenes* group. It has been demonstrated that this group of bacteria in the Tropics is ubiquitous. They are present in places far remote from any possible faecal pollution and this group of bacteria includes forms that are present in soil and vegetation, and which cannot be distinguished either by cultural or serologic methods from the same species encountered in faeces.(1)

On the other hand, it rarely happens, if ever, that true *B. coli* is isolated from water, nor is it found regularly in faeces of adult persons. A simple experiment showed us the difficulty of demonstrating true *B. coli* in water. We were repeatedly unable to demonstrate the presence of this bacterium in fishponds in which the fish population was thick and each fish examined contained true *B. coli* in the intestines, which could not be distinguished from *B. coli* of human origin, either by cultural or serologic reactions. The ubiquity of the representatives of the *aerogenes* group and the rare instances in which true *B. coli* is found in water weaken considerably the significance of the positive presumptive test and the negative *B. coli* test.

It has become a general practice to search for vibrios in waters in the Philippines where cholera is endemic and occurs to a more or less extent at regular intervals. Long years of experience taught us that cholera vibrios and choleralike vibrios will survive and multiply in water, particularly in sea water, for a long time.(2) Since artesian wells in the Philippines, particularly those in the lowlands along the shores, frequently contain salt, it was deemed advisable to test the water of artesian wells for vibrios in addition to the standard methods for water analysis.

Once the water becomes contaminated with the vibrios, they remain there alive for months. This fact may be utilized in sanitary water analysis as an anamnestic test. The contamination by surface water of artesian wells takes place most frequently

through the pump or the upper structure of the well. It is most likely to happen during the season of floods and rains. When vibrios get in the well under these circumstances, they will remain there for many months in spite of the fact that the colony count and the *B. coli* test may return to normal. The choleralike vibrios are different from true cholera vibrios, in two respects only; namely, they are not agglutinable by cholera serum, and when freshly isolated they are more strongly hæmolytic than freshly isolated cholera strains. They are coincident with true cholera vibrios in cholera fæces, which strongly indicates a close relationship between the two. Some vibrio strains isolated from waters could not be distinguished by cultural and serologic reactions from the choleralike vibrios isolated from convalescents and carriers. (2, 3, 4)

They can be, therefore, reasonably considered as an indication of fæcal contamination of various materials in cholera-endemic countries. Their regular increase in the fæces of a population immediately before the outbreak of cholera stamps them as greatly significant from the sanitary and epidemiologic standpoint. They may be found in waters and other materials such as food, vegetables, and drinks and can be demonstrated with far greater technical ease than any other intestinal pathogenic bacteria, due to their tolerance to alkaline reaction and on account of the enrichment process which allows them to overgrow other bacteria present in the material examined. We have, therefore, in the test for vibrios a very sensitive method for detecting fæcal pollution. Another advantage of this test for choleralike vibrios lies in the fact that it enables us to decide whether the well in question is being continuously contaminated or whether the contamination was caused by extraordinary circumstances, such as flood, poor mechanical condition of the pump, or improper protection of the head of the well, etc. If the contamination of the well is not continuous, the vibrios will disappear promptly after proper repairs have been made and after the well waters and the pump are disinfected with formalin. Should there be a permanent contamination through underground leakage, the vibrios will reappear repeatedly after the effect of the disinfectant has ceased.

CONCLUSION

In general, the artesian wells in Manila and vicinity supply water that meets the requirements of the standard for drinking waters. Whenever artesian wells show contamination, a

thorough examination of the mechanical parts of the well, proper repair of the pump, and proper protection of surroundings and thorough disinfection will assure further usefulness of the well. In the test for vibrios, we have an additional method, a very sensitive one, for detection of faecal pollution that is useful in cholera endemic countries.

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SPLEEN SURVEY OF THE EASTERN SHORE OF BATAAN PROVINCE, LUZON

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ONE TEXT FIGURE

Contemplated maneuvers of the Philippine Division made it necessary to survey the eastern shore of Bataan Peninsula, Luzon, to determine the prevalence of malaria along the proposed line of march of this division. Because of the relatively large area to be surveyed and the limited time within which the survey was to be accomplished, it was determined that a spleen survey, together with location of breeding places and identification of mosquitoes and larvæ, would furnish the information necessary.

Simmons, St. John, and Reynolds(1) have shown that splenomegaly in children is an excellent index of the prevalence of malaria in a community of Filipinos. In Fort Stotsenburg they found that 91 per cent of cases showing palpable spleens were suffering from malaria, while the same class of persons on Corregidor Island showed a positive finding of malaria in 52 per cent of cases. The percentage of positive cases rose sharply with the increased size of the spleens.

Bataan Peninsula forms the western boundary of Manila Bay, separating that body of water from the China Sea and forming the northwestern boundary of the North Channel entrance to Manila Bay. It is about thirty miles long and averages about ten miles in width. In the south of the peninsula are the Mari-veles Mountains, an extension of the Zambales Range of the north. Between the two ranges is a pass which allows free communication between the east and west coasts. The east coast consists of a flat plain of volcanic sand traversed by a large number of small rivers flowing from the mountains into Manila Bay. Most of the shore line is swampy. This portion

of the peninsula is inhabited by Tagalogs and Pampangos. There are no Caucasians. The eastern coastal plain varies in width from one-half mile to as much as seven or eight miles. The capital is Balanga, situated about midway the length of this plain, the population being about eight thousand. The population of the peninsula is about sixty thousand, about half of which live on the eastern shore where they are engaged in fishing and raising sugar cane. There are many fishponds in this area, which fact has an important bearing upon the mosquito population.

The survey party consisted of two doctors, two Filipinos trained in the collection and identification of adult mosquitoes and their larvæ, and a white sergeant whose duty it was to superintend the work of the field portion of the survey. Three days sufficed for the survey.

Permission was obtained from the Bureau of Education to examine school children in the towns of Dinalupihan, Hermosa, Orani, Samal, Abucay, Capitangan Barrio, Balanga, Cupang Barrio, Orion, and Limay. These centers of population in the order named, as will be noted on the map, are situated on the eastern plain from north to south. It was decided that the best procedure was to examine all the children in the first grade of each school visited. This would give a fairly complete cross section of the population and would provide a fairly accurate index of the rate of malarial infection in the whole population. The younger children were selected because rigidity of the abdominal muscles in the older groups interfered with palpation of the spleen.

Since attendance at school is voluntary it is certain that a rather high percentage of the older children did not attend school but inquiry indicated that a rather large percentage of the low age group did attend.

For the purpose of indicating the size of the splenic enlargement it was decided that all cases not palpable were to be called negative. If only palpable at the rib margin they were to be called P. I.; that is, palpable on inspiration. For spleens of larger dimensions the area on the abdominal wall between the symphysis pubis was divided into four parts by imaginary horizontal lines passing midway between the costal margin and the umbilicus, through the umbilicus, and midway between the umbilicus and the symphysis.⁽²⁾ Spleens, the margins of which were found in the areas above outlined, were numbered 1, 2, 3,

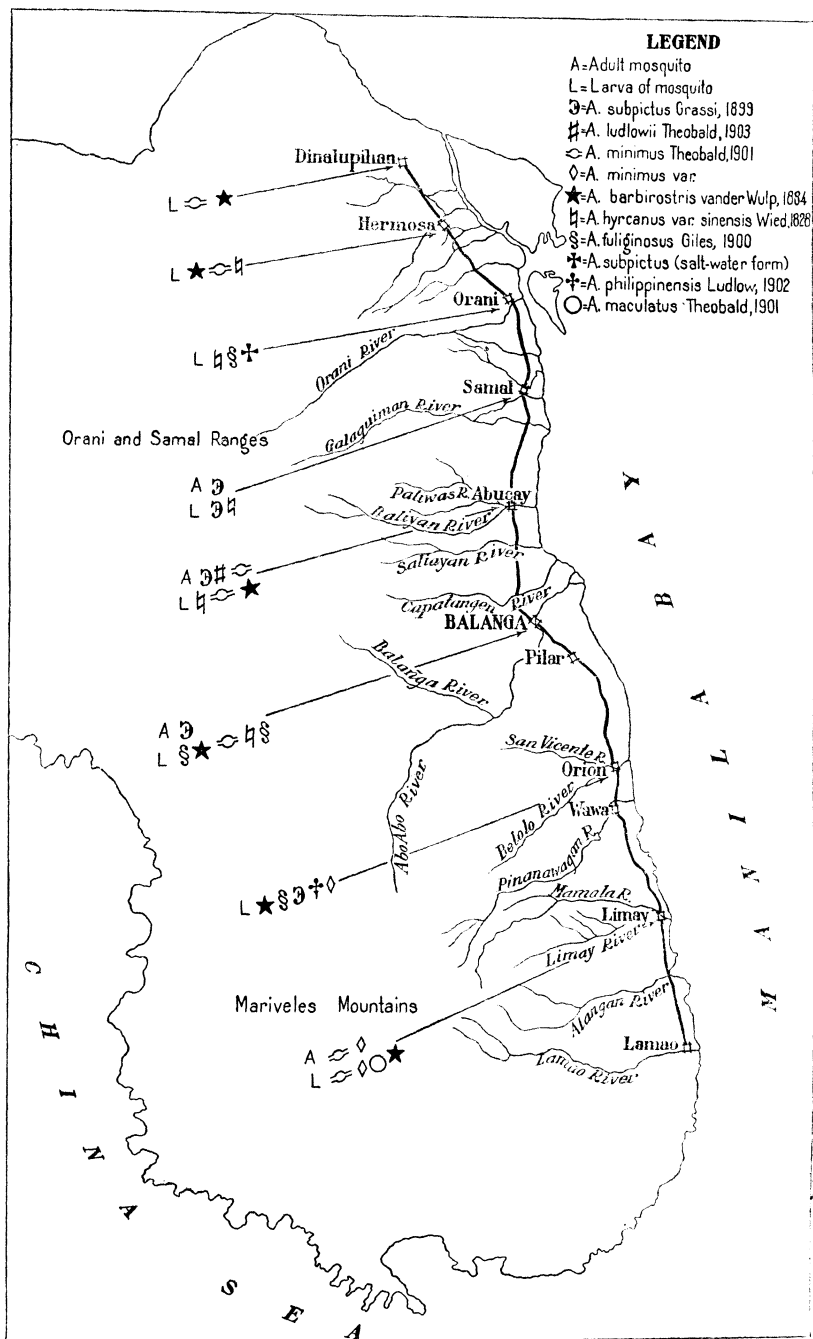


FIG. 1. A part of Bataan Province, Luzon, showing localities in which collections of mosquitoes were made.

and 4 from above downward. Thus, a No. 1 spleen was larger than a P. I. spleen but smaller than a No. 2.

Examination was made during full inspiration with the child lying on its back, knees flexed and hands folded on the chest. All examinations were made without the intervention of clothing. This was made easy by the scanty clothing worn by the children.

TABLE 1.—Spleen survey.

Town.	Sex.	Children examined.	P. I. spleens.	No. 1 spleens.	No. 2 spleens.	Per cent positive.	Total per cent.
Dinalupihan	M	16	4	0	2	37.5	30.5
	F	20	3	1	1	25	
Hermosa	M	68	2	0	1	4.4	7
	F	59	4	1	1	10	
Orani	M	69	2	1	0	4.3	5.5
	F	75	4	1	0	6.6	
Samal	M	55	3	0	0	5.4	6.5
	F	52	4	0	0	7.6	
Abucay	M	65	2	1	1	4.6	3.9
	F	37	1	0	0	2.7	
Capitangan Barrio	M	14	1	0	0	7.1	7.7
	F	12	1	0	0	8.3	
Balanga	M	66	5	0	3	12	11
	F	51	3	0	2	13	
Cupang	M	31	2	1	0	9.6	9.6
	F	0	0	0	0	0	
Orion	M	87	7	3	1	12.6	12
	F	65	4	2	1	10.7	
Limap	M	27	4	4	0	29	23
	F	29	4	1	0	17	

TABLE 2.—Mosquitoes collected during the survey.

Place.	Date.	Species.	Sex.		Remarks.
			♂	♀	
Samal	Nov. 4, 1930	<i>A. subpictus</i> fresh-water form	1	---	Captured among grasses.
Abucay	Nov. 5, 1930	do	2	1	Captured along the sides of the river banks.
		<i>A. ludlowi</i> Theobald 1903	3	2	
		<i>A. minimus</i> Theobald 1901	---	1	
		(<i>M. mangyana</i> Banks 1906. Probably <i>M. febrifera</i> Banks 1914).	---	---	
Balanga	Nov. 5, 1930	<i>A. subpictus</i>	1	---	Captured in house.
Limap	Nov. 6, 1930	<i>A. minimus</i> Theobald 1901	3	---	Captured along the sides of the river banks.
		<i>A. minimus</i> var. <i>flipinæ</i>	1	---	
		(Possibly <i>A. aconitus</i> Donitz 1902.)	---	---	

TABLE 3.—Mosquito larva survey.

Place.	Date collected.	Lot No.	Species.	Larvæ.	Remarks.
	1930				
Layac, Dinalupihan	Nov. 3	19	<i>A. minimus</i> Theo. 1901 (<i>M. mangyana</i> Banks 1906. Probably <i>M. flavirostris</i> Ludl. 1913. Probably <i>A. febrifera</i> Banks 1914). <i>A. barbirostris</i> Van der Wulp 1884	10	River, flowing, deep. Some bamboo roots, grasses, and débris.
Hermosa	Nov. 4	1	do	11	
		1	do	1	Fresh, flowing, clean water.
Do	Nov. 4	2	<i>A. minimus</i> Theo. 1901	1	Débris and grasses.
		2	Unidentified dead larvæ	3	Fresh, polluted, and flowing water.
Do	Nov. 4	3	<i>A. hyrcanus</i> var. <i>sinensis</i> Wied. 1828.	2	Fresh, still water, kiapo.
		3	do	1	Fresh water, kiapo.
Orani	Nov. 4	4	<i>A. fuliginosus</i> Giles 1900 (<i>Chagasia lineata</i> Ludl. 1908 and <i>Kerteszia mcgregori</i> Banks 1909).		
		4	do		
Do	Nov. 13	20	<i>A. subpictus</i> salt-water form (probably var. <i>indefinitus</i> Ludl. 1904).	144	Fishpond, salt water. Some chara and algæ.
		20	Unidentified larvæ (dead)	21	
		20	Pupæ	45	
		20	<i>A. subpictus</i> (salt water)	48	Small pool, salt water.
Do	Nov. 13	21	Unidentified dead larvæ	43	Some grasses.
		21	Pupæ	1	
Do	Nov. 13	22	<i>A. subpictus</i> (salt water)	173	Canal with still, salt water. Some grasses.
		22	Unidentified larvæ (dead)	59	
		22	do	49	Fishpond, salt water.
Do	Nov. 13	23	Unidentified dead larvæ	16	Some chara and algæ.
		23	Pupæ	27	
Samal	Nov. 5	5	<i>A. subpictus</i> Grassi 1899 (fresh water form).	3	Along sides of a canal. Fresh, still water with algæ.
		5	Unidentified dead larvæ	13	
Do	Nov. 5	6	<i>A. subpictus</i> (fresh water)	13	Fresh marsh water with algæ.
		6	Unidentified dead larvæ	7	
Do	Nov. 5	7	<i>A. hyrcanus</i> var. <i>sinensis</i>	1	Fresh and flowing water with grasses and kiapo.
Abucay	Nov. 5	8	<i>A. hyrcanus</i> var. <i>sinensis</i>	9	Along sides of a canal.
		8	Unidentified dead larvæ	11	Fresh, flowing, dirty water with grasses and débris.
		8	do		
Do	Nov. 5	9	<i>A. minimus</i> Theo. 1901	10	River, flowing, fresh, clean, shady; some grasses and débris.
		9	<i>A. barbirostris</i>	3	
		9	Unidentified dead larvæ	4	

TABLE 3.—Mosquito larva survey—Continued.

Place.	Date collected.	Lot No.	Species.	Larvæ.	Remarks.
	1930				
Abucay.....	Nov. 5	10	Unidentified dead larvæ..	2	Small pool, fresh water.
Balanga.....	Nov. 5	11	<i>A. fuliginosus</i>	5	Fresh, still water
			Unidentified dead larvæ..	2	with kiapo and grasses.
Cupang, Balanga....	Nov. 5	12	<i>A. barbirostris</i>	9	Along sides of a canal
			<i>A. minimus</i> Theo. 1901....	1	with fresh, flowing
			Unidentified dead larvæ..	6	and clean water.
					Some grasses and débris.
Do.....	Nov. 5	13	<i>A. hyrcanus</i> var. <i>sinensis</i> ..	2	Fresh, still water
			<i>A. fuliginosus</i>	1	with kiapo and
			Unidentified dead larvæ..	6	grasses.
Orion.....	Nov. 5	14	<i>A. barbirostris</i>	5	Do.
			<i>A. fuliginosus</i>	1	
			Unidentified dead larvæ..	3	
Do.....	Nov. 5	15	<i>A. subpictus</i> (fresh water)	69	Small pool with fresh water.
			Unidentified dead larvæ..	34	Some algæ.
			<i>A. barbirostris</i>	8	Along sides of canal.
			<i>A. fuliginosus</i>	20	Fresh flowing
			<i>A. philippinensis</i> Ludl. 1902.	2	water. Some algæ,
Do.....	Nov. 5	16	<i>A. minimus</i> var. (possibly <i>A. aconitus</i> Donitz 1902.	1	kiapo, chara, and grasses.
			<i>A. subpictus</i> (fresh water)	1	
			Unidentified dead larvæ..	5	
Do.....	Nov. 6	17	<i>A. subpictus</i> (fresh water)	11	Fresh, still water
			Unidentified dead larvæ..	4	with algæ.
			<i>A. minimus</i> Theo. 1901....	9	Along sides of a
			<i>A. minimus</i> var. <i>aconitus</i> ..	23	rocky river with
Limay.....	Nov. 6	18	<i>A. maculatus</i> Theo. 1901..	1	clean flowing and
			<i>A. barbirostris</i>	5	partly shaded
			Unidentified dead larvæ..	19	water. Some bam-boo roots, grasses, algæ, and débris.

Eight hundred ninety-eight children were examined, of which there were five hundred two males and three hundred ninety-six females.

Of the five hundred two males eighty-one were over 9 years of age and four hundred twenty-one were between 6 and 9 years of age.

Of the three hundred ninety-six females thirty-seven were over 9 years of age and three hundred fifty-nine were between 6 and 9 years of age.

Total children over 9 years of age, one hundred eighteen. Total children between 6 and 9 years of age, seven hundred eighty.

The preceding tables show the results of the survey.

CONCLUSIONS

No spleen larger than a No. 2 was found during the survey. Several striking features are evident—one is that the nearer the town is located to the foothills of the mountains the higher is the splenic rate. This is particularly noticeable in Dinalupihan, with a splenic rate of 30.5 per cent and in Limay with a splenic rate of 23 per cent, these two towns being the only two of those noted in Table 1 that are situated directly in the foothills. Without exception cases found at towns other than these two resided in the interior of the peninsula and not on the coastal plain. From this fact we are led to conclude that malaria does not exist on the eastern coastal plain of Bataan except as imported from the foothills.

Anopheles ludlowii is commonly encountered in the salt-water marshes of this region, but is not a vector of malaria in this locality. Our mosquito and larva survey was confined to an attempt to determine the presence or absence of *A. minimus* in this region. While this mosquito was found in Hermosa, Abucay, Cupang, and Limay, it is apparent that it is not an effective vector of malaria in any of these localities, except Limay, since the population did not show any considerable splenic index. The population of Dinalupihan showed plainly the presence of malaria in a considerable percentage of the residents, although the intensity of the infection was not great.

These findings are in sharp contrast with the work of Ash in 1922 who examined cases at all the towns mentioned and found only two positive spleens in one hundred ninety-one cases examined. We are inclined to believe that the discrepancy is due to the fact that there is a much greater attendance of school children from the foothills than there was eight years ago and that there is no actual increase in malaria except in cases residing off the coastal plain.

NOTE

The classification of the anophelines used in this article is that of Dr. W. V. King. This classification is of temporary character.

Grateful acknowledgment is made of valuable assistance rendered in this survey by Serg. Lloyd Stevens, Medical Depart-

ment, United States Army; Mr. Domingo Santiago, field inspector for malaria investigations, Bureau of Science; and Private 1st class Bonifacio Reyes, Medical Department (PS), United States Army.

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ILLUSTRATION

TEXT FIG. 1. Map of a part of Bataan Province, Luzon, showing localities
in which collections of mosquitoes were made.

FURTHER EXPERIMENTS CONCERNING IMMUNITY IN TREPONEMATOUS INFECTIONS¹

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ONE TEXT FIGURE

The experiments given in this communication were undertaken for the purpose of extending previous findings made on Philippine monkeys concerning homologous immunity to yaws, cross immunity between syphilis and yaws, and immunity to yaws resulting from immunization with yaws and syphilis vaccine. This investigation, therefore, treats of the same problems as those presented in our published experiments.

ADDITIONAL EXPERIMENTAL EVIDENCE SHOWING THAT INFECTION WITH SYPHILIS IMMUNIZES PHILIPPINE MONKEYS AGAINST YAWS

A somewhat different experimental procedure was adopted in this experiment than in previous ones dealing with this question.² Instead of intradermal inoculation with syphilis, as previously employed, intratesticular or intramuscular inoculation with syphilis was used in this experiment. Thus an infection with syphilis was produced in the monkeys that was different from the infection produced in former experiments in so far as syphilitic lesions on the integument did not develop in the monkeys included in the present experiment.

Through this experiment it was intended to prove the correctness of previous findings and to obtain information on whether or not cross immunity to yaws develops in syphilitic monkeys under such conditions of experimental inoculation, which is different from the natural way that the syphilitic infection invades the fully susceptible human body tissues but which may be reasonably expected to occur at times in partially immune cases upon reinfection following cure.

¹ Received for publication February 5, 1931.

² Philip. Journ. Sci. 43 (1930) 583.

As was to be expected, the inoculation with syphilis of Philippine monkeys did not produce generalized manifestations. The treponemas remained lodged in the tissues where they were placed by the injection and wandered into the lymphatics without producing clinical manifestations. Consequent to the mesodermotropic proclivity of the treponema of syphilis, the cross immunity developed about the same time in those cases in which intradermal inoculation was employed and primary syphilitic skin lesion developed as it did in the present experiment, when inoculation was performed into the mesoderm.

One monkey infected with syphilis by intratesticular inoculation was found susceptible to yaws six months after the inoculation with syphilis. Two others inoculated in the same way and one inoculated also with syphilis but by intramuscular injection were found immune to yaws when inoculated ten and again eleven months after the first inoculation with syphilis.

The serologic findings in these animals are interesting. In the absence of initial skin lesions the early serologic response to inoculation with syphilis was absent in all the animals tested; the late response, on the other hand, was as strong as the one observed in syphilitic monkeys with initial skin lesions (Fig. 1).

Guided by our previous observation that the high degree of group immunity in experimental treponematoses sets in at the time when the late serologic response has reached the highest point and has remained there, we have timed the tests for immunity to yaws accordingly in the last three monkeys used in this experiment (see table 1).

CONCLUSIONS

1. Syphilitic infection conveyed to Philippine monkeys by intramuscular or intratesticular inoculation without formation of apparent lesions, either initial or generalized, immunizes these animals against cutaneous inoculation with yaws.

2. Due to mesodermotropic preference of the parasite of syphilis, the cross immunity to yaws in Philippine monkeys inoculated with syphilis under these conditions developed about the same time as it did when monkeys were infected by intradermal inoculation with syphilis and when initial skin lesions developed.

3. The results of this experiment confirm those obtained in former experiments³ concerning immunologic reciprocity between syphilis and yaws.

³ Philip. Journ. Sci. 43 (1930) 583.

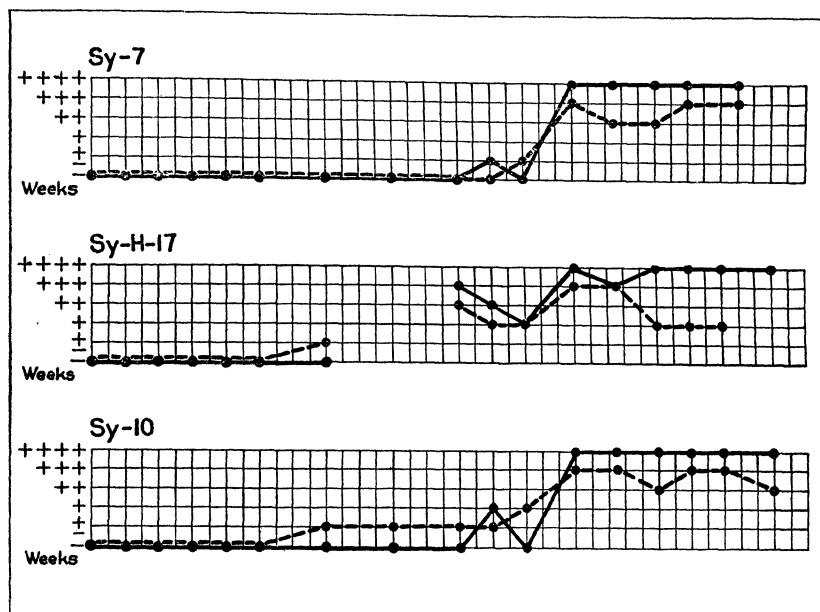


FIG. 1. Showing the serologic response to intramesodermal infection with syphilis in Philippine monkeys.

EXPERIMENTAL EVIDENCE SHOWING THAT MESODERMAL INOCULATION WITH YAWS IMMUNIZES AGAINST EPIDERMAL INFECTION WITH YAWS

This experiment with yaws was arranged in a similar way to the preceding one with syphilis. Two monkeys were inoculated with yaws by intramuscular injection and one by intratesticular injection. One control was inoculated intradermally with the same amount of the same yaws inoculum to test the viability of the treponemas. While the animals that were inoculated by intramuscular and intratesticular inoculation did not develop clinical yaws lesions, the control animal inoculated by intradermal injection developed typical yaws showing that the inoculum contained viable treponemas. The test for immunity by intradermal inoculation with yaws was performed three and four months after the mesodermal infection, that is, four and three months earlier than immunity to yaws develops in Philippine monkeys following epidermal inoculation with yaws. The test for immunity was confirmed. Normal control animals were included in the test for immunity (see table).

The result of this experiment shows that inoculation with treponema of yaws placed in the mesoderm in such a manner that no clinical yaws lesions develop, immunizes monkeys against

subsequent intradermal infection with yaws in a much shorter time than the intradermal inoculation that is followed by development of specific lesion. The yaws immunity develops after mesodermal inoculation just as quickly as it does after generalization of the yaws process in Philippine monkeys.

CONCLUSION

This experiment confirms and amplifies our previous findings⁴ that intramesodermal inoculation with yaws without skin lesion confers immunity to yaws much earlier than does intradermal inoculation followed by development of cutaneous lesions.

AN EXPERIMENT CONCERNING PREVENTIVE IMMUNIZATION WITH LIFELESS SYPHILIS AND YAWS VACCINE

This experiment offers additional evidence to prove that preventive vaccination against treponematoses has a decided effect on the course of subsequent infection.⁵

Two monkeys (K-33 and K-34) received two subcutaneous injections of syphilis vaccine (Nichols' strain), rich in treponemas and heated at 60° C. for 30 minutes. The first vaccination was given on December 9, 1929, and the second, eight days later. On April 24, 1930, both animals were each given one subcutaneous injection of yaws vaccine, killed by heating to 60° C. for one hour.

On June 3, 1930, the two vaccinated animals, together with one normal control animal were inoculated by intradermal injection with the same amount of yaws inoculum on both eyebrows. The intradermal inoculation with living yaws material was performed six months after the first vaccination with killed syphilis vaccine and about six weeks after the last vaccination, that is, with the killed yaws vaccine.

On June 23, that is three weeks after the inoculation, the control monkey developed typical clinical yaws at the places of inoculation. These lesions ran a typical course and contained numerous treponemas.

The two vaccinated monkeys were observed for a period of more than six months after the inoculation. Monkey K-33 did not show any sign of lesion and monkey K-34 developed a dry desquamative lesion on one eyebrow in which no treponemas were found on repeated examinations. The lesion develop-

⁴ Philip. Journ. Sci. 35 (1928) 295.

⁵ Philip. Journ. Sci. 42 (1930) 219.

ed July 28, 1930, and was completely healed on August 25 of the same year.

The vaccination with killed vaccine in this experiment had the effect that upon subsequent inoculation one animal developed no lesion at all, while the other of the two vaccinated monkeys showed no lesion at one point of inoculation and a short lived desquamative framboeside without demonstrable treponemas at another point of inoculation; a lesion which we found in partially immune monkeys as the last outcrop of generalized dissemination⁶ and in experimental human volunteers as a result of superinfection at the place of superinoculation which was performed in the late part of the secondary stage,⁷ that is at a time when a considerable degree of immunity has developed in the course of yaws infection.

CONCLUSIONS

1. Preventive immunization with killed syphilis and yaws vaccine confers a high degree of antitreponematous immunity to normal Philippine monkeys.

2. The immunologic reciprocity between syphilis and yaws is again evident from the results of this experiment.

3. The result of this experiment is in agreement with those of our previous ones concerning preventive vaccination and vaccine-therapy.⁸

AN EXPERIMENT SHOWING THE IMMUNOLOGIC EFFECT OF MESODERMAL REINFECTION WITH YAWS PERFORMED AFTER SPECIFIC TREATMENT HAS BEEN GIVEN IN THE EARLY STAGE OF INITIAL YAWS LESION

Two Philippine monkeys were inoculated simultaneously with the same amount of the same yaws inoculum by intradermal injection, July 23, 1930. Four weeks after the inoculation typical papular lesions containing treponemas, developed in both animals. Neosalvarsan treatment was given September 2, 1930. The lesions healed in a week after the first therapeutic injection. September 30, 1930, one of the monkeys (Le. No. 1) was reinoculated with yaws by intramuscular injection. The animals were inspected weekly and no sign of yaws was found from the time the animals were cured. November 3 both monkeys were inoculated simultaneously on both eyebrows by intradermal injection with the same amount of the same yaws

⁶ Philip. Journ. Sci. 35 (1928) 231.

⁷ Philip. Journ. Sci. 30 (1926) 463.

⁸ Philip. Journ. Sci. 42 (1930) 219; 43 (1930) 603.

inoculum as a test for immunity. December 2, that is, four weeks after the last intradermal inoculation, an oozing typical lesion containing treponemas was found on both eyebrows of monkey K-35. This animal was treated in the early stage of initial yaws and received no further inoculation. The other yaws monkey of this experiment (Le. No. 1), which was similarly treated but was reinfected by intramuscular injection of living yaws treponemas subsequent to specific cure, developed no lesion at the place of the last intradermal inoculation with yaws performed as a test for immunity. A confirmatory test for immunity was performed on December 24 of the same year and the viability of the inoculum was tested on one normal control monkey. This test confirmed the result of the previous test.

SUMMARY

Two Philippine monkeys inoculated by intradermal injection with yaws were treated with neosalvarsan in the early stage of initial yaws. One of the two animals received an intramuscular injection of living treponemas of yaws ten weeks after the original inoculation with yaws and following the treatment. Both animals were subjected to a test for immunity by intradermal inoculation with yaws four months and one week after the original inoculation with yaws. The animal that was reinfected with yaws by intramuscular injection proved to be immune, while the other yaws monkey that was similarly treated but not reinfected was found susceptible at that time. Confirmatory test confirmed the previous test (see Table 4).

CONCLUSIONS

1. Intramesodermal incorporation of treponema-antigen performed on early cured yaws monkeys hastens the development of antitreponematous immunity. It prevents subsequent reinfection and consequently it prevents the development of subsequent stages of the treponematous infection.

2. While intradermal superinfection with yaws does not accelerate the immunity induced by the primary lesion in the course of an infection, intramesodermal superinfection with yaws, like the generalization of yaws (the secondaries), or like vaccine-therapy, or like a superinfection with mesodermotropic treponema of syphilis, accelerates the development of immunity to yaws.

3. The result of this experiment confirms our previous findings concerning vaccine-therapy in treponematous infections.⁹

⁹ Phillip. Journ. Sci. 43 (1930) 603.

TABLE 1.—Showing the result of intradermal inoculation with yaws performed on Philippine monkeys that have been infected with syphilis by intratesticular or intramuscular injection.

[+, lesion; —, no lesion; 0, not done.]

Designation of monkey.	Inoculated with syphilis.		Inoculated with yaws.		Re-sult.
	Date.	Mode.	Date.	Mode.	
Sy-2.....	{ V-24-28 V-15-29 VI-28-29 V-15-29 }	Intratesticular.....	XI-13-28	Intradermal.....	+
Sy-7.....		do.....	III-24-30	do.....	—
Sy-H-27.....		do.....	IV-21-30	do.....	—
Sy-10.....		do.....	III-24-30	do.....	—
	{ V-15-29 VI-28-29 0 0 }	Intramuscular.....	IV-21-30	do.....	—
		do.....	III-24-30	do.....	—
Yac-23 Control.....		do.....	III-24-30	do.....	+
Yac-24 Control.....		do.....	IV-21-30	do.....	+

* These letters and figures indicate month, day, and year; thus, V-24-28 means May 24, 1928.

TABLE 2.—Showing the rapid development of yaws immunity following intramedullary inoculation with yaws.

[+, lesion; —, no lesion; 0, not done; ?, no lesion; D, died.]

Designation of monkey.	Inoculated with yaws.			Inoculated with yaws (test for immunity).			Remark.
	Date.	Mode.	Result.	Date.	Mode.	Result.	
Ya intramuscular No. 1.....	a III-13-30	Intramuscular.....	?	VI- 5-30	Intradermal.....	—	D VII-22-30.
Ya intram No. 2.....	III-13-30	do.....	?	{} VII- 8-30	do.....	—	
				{} X-30-30		—	
Ya intratest L No. 2.....	III-13-30	Intratesticular.....	?	{} VII- 8-30	do.....	—	
				{} X-30-30		—	
Ya-C-22.....	III-13-30	Intradermal.....	+	VI- 5-30	do.....	+	
Ya-C-29.....	0			VII- 8-30	do.....	+	
Ya-C-32.....	0			X-30-30	do.....	+	
Ya-Control.....	0						

a These letters and figures mean month, day, and year; thus, III-13-30 means March 13, 1930.

TABLE 3.—Showing the results of inoculation with yaws performed on monkeys immunized with killed syphilis-yaws vaccine.

[+, positive take, treponemas present; —, negative take, treponemas not found; ±, frameside; v, vaccine.]

Designation of monkey.	Vaccinated subcutaneously with 60° C. vaccine.				Inoculated with yaws (test for immunity).		
	Syphilis vaccine.		Yaws vaccine.		Date.	Re-sult.	Treponemas.
	XII- 9-29	XII-17-29	IV-24-30	IV-24-30			
K-33.....	XII- 9-29	XII-17-29	IV-24-30	IV-24-30	VI- 3-30	—	—
K-34.....	XII- 9-29	XII-17-29	IV-24-30	IV-24-30	VII- 1-30	±	—
Ya-C-28.....	0	0	0	0	VI- 3-30	+	+
Ya-C-30.....	0	0	0	0	VII- 1-30	+	+

a These letters and figures mean month, day, and year; thus, XII-9-29 means December 9, 1929.

TABLE 4.—Showing the immunologic effect of intramesodermal inoculation with yaws performed after specific treatment given in the early stage of initial yaws.

[+, positive take; —, negative take; 0, not done.]

Designation of monkey.	Inoculated with yaws (intradermal).		Specific treatment.	Inoculated with yaws (intramuscular).	Intradermal test for immunity to yaws.	
	Date	Re-sult.			Date.	Re-sult.
Le-No. 1.....	*VII-23-30	+	IX-20-30	IX-30-30	XI-3-30	—
K-35.....	VII-23-30	+	IX-20-30	0	XII-24-30	—
Ya-C-38 Control.....	0	-----	0	0	XI-3-30	+
					XII-24-30	+

* These letters and figures mean month, day, and year; thus, VII-23-30 means July 23, 1930.

ILLUSTRATION

TEXT FIG. 1. Chart showing the serologic response to intramesodermal infection with syphilis in Philippine monkeys.

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PHILIPPINE TURPENTINE FROM *PINUS INSULARIS* (ENDLICHER)

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and

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TWO PLATES

The Benguet pine (*Pinus insularis* Endlicher) forms extensive forests in the mountain regions of northern Luzon. Recently we investigated samples of resin tapped from the Benguet pine, and our results showed that an excellent quality of turpentine of high pinene content is obtained from it.

Turpentine consists essentially of a mixture of terpenes. Alpha pinene, which may be separated from turpentine by distilling is, at present, the chief source of synthetic camphor.¹

Turpentine is used principally for paint and varnish thinners. More than 80 per cent of the total output is used for this purpose. It is also used in the manufacture of shoe polish, leather dressing, automobile oils and greases, sealing wax, and pharmaceutical and chemical supplies.

During the year 1928 a total of more than 5,000,000 gallons of turpentine was consumed² in the United States, and over 14,000,000 gallons was exported.³

Information concerning the cultivation of pine trees and the production and uses of turpentine is given by various Government publications such as farmers' bulletins on longleaf pine, slash pine, and pine nursery stock.⁴

¹ Journ. Ind. Eng. Chem. News Ed. 8 (1930) 8.

² Chem. Met. Eng. 37 (1930) 196.

³ Yearbook U. S. Dept. Agr. 1930, 944.

⁴ Mattoon, W. R., U. S. Dept. Agr. Farmers' Bull. 1256 (1922); 1486 (1926).

Wakeley, P. C., U. S. Dept. Agr. Leaflet 32 (1929); 35 (1929).

Wyman, L., Florida Dept. Agr. Bull. 25 N. S. (1929).

Hayes, R. W., and P. C. Wakeley, Louisiana State Univ. Bull. 21 N. S. No. 3, pt. 2 (1929).

Veitch, F. P., and V. E. Grotlisch, U. S. Dept. Agr. Bull. 898 (1920).

Recently, there have appeared two articles ⁵ that give a very good resumé of the present status and future prospects of the turpentine industry.

In 1929, more than 79,000 kilograms of turpentine, valued at over 26,000 pesos, were imported into the Philippines.⁶ Most of this came from the United States.

Turpentine obtained from the resin of Benguet pine trees has been investigated by Richmond ⁷ and also by Brooks.⁸ The trees selected for their investigations were growing near Baguio, a summer resort situated at an elevation of about 1,500 meters in the mountain province of the Philippines. Their results showed that some of the trees gave fair yields of turpentine while others gave rather poor yields. According to Brooks, turpentine from the Benguet pine trees consists principally of pinene and compares favorably with American turpentine.

EXPERIMENTAL PROCEDURE

Since these preliminary investigations, carried out some years ago, gave promising results it seemed desirable to continue this work.

During the spring of 1930, J. Fontanoza and P. D. Esguerra, foresters of the Philippine Bureau of Forestry, tapped a number of Benguet pine trees in and near Baguio. The resin obtained from these trees was then shipped to the Bureau of Science laboratories in Manila where we made an investigation of it.

In Table 1 are given the location and the approximate diameter of the pine trees selected for this investigation. The dates of tapping the trees, the number of chippings, and the yield of resin obtained are also included. As shown by the data, trees of various sizes were selected for our experiments.

The cup and gutter method was employed by the foresters in tapping and chipping the pine trees. The procedure was essentially the same as that described some years ago by Herty⁹ except that somewhat different kinds of tools were used. For

⁵ Speh, C. F., *Journ. Chem. Ed.* 7 (1930) 2322.

Bent, L. N., *Journ. Chem. Ed.* 7 (1930) 2365.

⁶ *Annual Report, Insular Collector of Customs, Manila, (1929).*

⁷ *Philipp. Journ. Sci.* § A 4 (1909) 231.

⁸ *Philipp. Journ. Sci.* § A 5 (1910) 229.

⁹ U. S. Dept. Agr. Forest Service Bull. 40 (1903) 17.

TABLE 1.—Location and diameter of Philippine trees selected for collecting Benguet pine resin.

Tree No.	Location.	Diameter. ^a	Date of tapping.	Duration of chipping.	Number of chippings.	Yield of resin.
		cm.	1930.	1930.		g.
1	Forbes Park	40.5	Jan. 22	Jan. 29 to July 30 ..	27	574.0
2	do	37.0	do	do	27	505.6
3	do	37.5	do	do	27	1,898.0
4	do	33.5	do	do	27	882.8
5	do	48.5	do	do	27	1,220.6
6	do	57.5	do	do	27	1,346.5
7	Irisan, near Naguilian Road.	42.5	Feb. 10	Feb. 17 to July 31 ..	27	1,137.9
8	do	41.0	do	do	27	883.2
9	do	35.5	do	do	27	1,779.5
10	do	34.0	do	do	27	975.4
11	do	46.0	do	do	27	2,463.6
12	do	57.0	do	Feb. 17 to July 30 ..	35	2,448.3
13	do	38.0	do	do	35	1,753.1
14	do	47.0	do	do	35	1,338.6
15	do	42.0	do	do	35	1,471.4
16	do	51.0	do	do	35	3,037.3
17	Pimmarioc, Trinidad.	42.0	Apr. 25	May 2 to July 29 ..	34	1,123.6
18	do	62.0	do	do	34	3,683.1
19	do	64.5	do	do	34	1,001.6
20	do	61.0	do	do	34	1,136.8
21	do	66.0	do	do	34	917.4

^a The diameters of the trees were measured at a height of 1.3 meters from the ground.

instance, instead of using a broad ax, a heavy bolo served the same purpose. After the first cut (streak) is made in the trees most of the resin usually flows out during the first day and very little is obtained during the next few days. When the first cut is extended by a second chipping the resin begins to flow freely again for another day. By making new chippings frequently and continually lengthening the original cut the tree continues to yield resin for some months. A day or so after a new chipping, when the exudation had practically stopped, the resin was poured (dipped) from the tree cup into a permanent container.

As shown by the data (Table 1) the yield of resin from individual trees varies considerably.

Altogether twenty-one trees were tapped. The total resin obtained from the first tapping of these trees was combined into a composite sample (composite No. 1). Subsequently a number of these trees were tapped a second time. When these various

samples of pine resin were received in our laboratory in Manila, they were first steam distilled to separate the turpentine from the rosin. After distillation the turpentine was separated from the admixed water and dried with calcium chloride. After draining off the water the rosin was dried in desiccators. The percentage yields of turpentine and rosin obtained from the pine resin are given in Table 2.

TABLE 2.—*Turpentine and rosin obtained from Benguet pine trees.*

Sample. ^a	Turpen- tine.	Rosin.
	Per cent.	Per cent.
Tree No. 3.....	15.33	84.67
Tree No. 5.....	17.02	82.98
Tree No. 9.....	16.18	83.82
Tree No. 18.....	17.47	82.53
Composite No. 1.....	14.58	85.42
Composite No. 2.....	16.57	83.43
Composite No. 3.....	17.23	82.77
Average.....	16.34	83.66

^a Samples for trees 3, 5, 9, and 18 were obtained from a second tapping.

Composite 1: Combined resin from the first tapping of trees 1 to 21.

Composite 2: Combined resin from the second tapping of trees 18, 20, and 21.

Composite 3: Combined resin from a second tapping of trees 10, 12, and 16.

According to Wyman ¹⁰ the yield of resin from pine trees varies considerably, depending upon such factors as soil, weather, size of trees, species, etc. In general, the quantity of resin obtained from a tree varies directly with the size of the tree and the highest yields are obtained in the hot dry season, which permits of long continuous working.

In Florida, pine-tree resin when distilled yields an estimated average of one barrel of turpentine for three and a third barrels of rosin. Expressed in percentage that would be: 23.09 per cent of turpentine to 76.91 per cent of rosin by volume. According to our results (Table 2), Benguet pine-tree resin gave 16.34 per cent of turpentine to 83.66 per cent of rosin by weight, which would be equivalent to 20.93 per cent of turpentine to 79.07 per cent of rosin by volume. This is about a barrel of turpentine to three and four-fifths barrels of rosin. It would seem that in the Philippines the yield of turpentine from Benguet pine trees is somewhat less than in Florida while the yield of rosin is slightly greater.

In Table 3 are given the constants of Benguet turpentine.

¹⁰ Florida Dept. Agr. Bull. 25 N. S. (1929) 33.

TABLE 3.—Constants and distillation of Benguet turpentine.

Sample. *	Specific gravity 30° C. 4° C.	Specific rotation 30° C. ($\frac{A}{D}$)	Refractive index 30° C. ($\frac{N}{D}$)	Distillation. °C.				
				Below 155°.	155-157°	157-159°	159-160°	Residue.
				Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Tree No. 3..	0.8475	+30.2	1.4650	3.33	52.0	13.33	12.0	16.44
Tree No. 5..	0.8473	+32.1	1.4644	2.60	45.15	16.50	21.70	14.00
Tree No. 9..	0.8480	+27.05	1.4665	8.8	61.4	7.8	7.6	11.4
Tree No. 18.	0.8488	+32.07	1.4650	10.2	66.0	4.8	4.6	12.4
Composite 1.	0.8483	+29.65	1.4653	0.2	69.6	11.8	5.0	11.2
Composite 2.	0.8495	+28.02	1.4668	3.0	38.4	19.2	9.4	28.0
Composite 3.	0.8630	+22.75	1.4716	1.2	30.4	20.4	18.0	27.4

* Samples for trees 3, 5, 9, and 18 were obtained from a second tapping.

Composite 1: Combined resin from the first tapping of trees 1 to 21.

Composite 2: Combined resin from a second tapping of trees 18, 20, and 21.

Composite 3: Combined resin from a second tapping of trees 10, 12, and 16.

Turpentine obtained from the resin of Benguet pine trees is water white in color and has a very pleasant aromatic odor. The data given in Table 3 indicates that Benguet turpentine has a high pinene content (B. P. 155 to 157° C.). It would also appear that samples obtained from different trees seem to vary considerably in composition. This may be due in part to the method of collecting the resin. Some of the samples were exposed to the air longer than others and perhaps suffered a greater degree of oxidation and evaporation.

In Table 4 are given the constants of the pinene fraction (B. P. 155 to 157° C.) of Benguet turpentine. A sample of this fraction was cooled in ice and treated with dry hydrochloric acid gas. The white crystals of pinene hydrochloride thus obtained gave a melting point of 125° to 126° C. Watts gives 125° C. as the melting point of pure pinene hydrochloride.¹¹

The authors wish to thank Mr. Arthur F. Fischer, director, Philippine Bureau of Forestry, and Mr. Luis J. Reyes, chief, division of forest products, Bureau of Forestry, for their co-operation and assistance in this work on the chemistry of forest products.

The authors also wish to thank Mr. P. D. Esguerra, forester of the Philippine Bureau of Forestry, for help in procuring samples of Benguet pine resin for this investigation. To Mr. Aurelio Cruz, of the Bureau of Science, for assistance in determining the constants of turpentine the authors are also indebted.

¹¹ Dictionary of Chemistry 4 (1927) 663.

TABLE 4.—*Constants of Benguet turpentine (pinene fraction-boiling point 155 to 157° C.).*

Sample.	Specific gravity 30° C. 4° C.	Specific rotation 30° C. $\left(\frac{A}{D}\right)$	Refractive index 30° C. $\left(\frac{N}{D}\right)$
Tree No. 3.....	0.8498	+35.03	1.4635
Tree No. 5.....	0.8558	-----	1.4650
Tree No. 9.....	0.8480	+30.7	1.4645
Tree No. 18.....	0.8491	+34.0	1.4637
Composite 1.....	0.8524	+33.71	1.4640
Composite 2.....	0.8509	+32.88	1.4641
Composite 3.....	0.8518	+33.15	1.4638

SUMMARY

We have investigated the turpentine obtained from the resin of Benguet pine trees growing at Baguio in the mountain province of the Philippines.

The yield of pine resin from these trees varies considerably.

The yield of Benguet turpentine is somewhat less than the yield obtained from the resin of Florida pine trees.

Samples of turpentine from the pine resin of different Benguet trees seem to vary considerably in composition.

Benguet turpentine has a high pinene content.

The pinene fraction of Benguet turpentine, obtained from the resin of different pine trees, seems to vary considerably in physical properties.

ILLUSTRATIONS

- PLATE 1.** Philippine pine trees in Baguio.
2. Tapping a pine tree.



PLATE I. PHILIPPINE PINE TREES IN BAGUIO.



PLATE 2. TAPPING A PINE TREE.

MALARIA TRANSMISSION IN THE PHILIPPINES, I THE NATURAL VECTOR ¹

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ONE PLATE AND ONE TEXT FIGURE

In a preliminary note on malaria transmission,² dissection for malarial parasites of about 2,700 anophelines caught in La Mesa and South Portal camps (Novaliches water project), Rizal Province, Luzon, from September to December, 1927, was reported. Table 1 shows the number of each species dissected at the time and the results.

TABLE 1.—*Mosquitoes dissected in 1927.*

Species.	Total mosqui- toes.	Stomachs posi- tive.		Salivary glands.	
		Number.	Per cent.	Number.	Per cent.
<i>Anopheles funestus (minimus)</i>	2,283	19	0.83	8	0.35
<i>Anopheles hyrcanus</i>	77	0	.00	0	.00
<i>Anopheles barbirostris</i>	60	0	.00	0	.00
<i>Anopheles rossii</i>	41	0	.00	0	.00
<i>Anopheles karwari</i>	27	0	.00	0	.00
<i>Anopheles tessellatus</i>	5	0	.00	0	.00
<i>Anopheles fuliginosus</i>	194	0	.00	0	.00
<i>Anopheles philippinensis</i>	5	0	.00	0	.00
<i>Anopheles maculatus</i>	1	0	.00	0	.00

The table shows that *Anopheles minimus* Theobald (*A. fef-rifera* Banks, of Walker and Barber), which we now call *A. funestus*,³ was the only species found naturally infected. The figures, however, were not satisfactory, 84 per cent being *fun-estus* while the numbers of the other species examined were small and inconclusive, particularly with regard to *A. ludlowi* Theobald (none). Banks'⁴ positive experimental work on *A.*

¹ From the field laboratory, division of malaria control, Philippine Health Service, Tungkong Manga, San Jose del Monte, Bulacan, Luzon.

² Manalang, C., Philip. Journ. Sci. 37 (1928) 123.

³ Manalang, C., Philip. Journ. Sci. 43 (1930) 247.

⁴ Philip. Journ. Sci. § B 2 (1907) 513.

ludlowi (salt-water type) in Olongapo, Bataan, should be discarded altogether because he mistook the thoracic ganglion for the salivary gland and the neural nuclei of the thoracic ganglion for sporozoites as he showed them in microphotographs of his mosquito sections.⁵ In his mosquito survey of Cervantes,⁶ Ilocos Sur, an inland mountainous district, he also incriminated the fresh-water *ludlowi* on the strength of his findings in Olongapo. Walker and Barber⁷ infected experimentally *A. febrifera* Banks (*minimus*) and *A. maculatus* Theobald. Tiedeman⁸ and Mieldazis⁹ suspected *ludlowi* (fresh water) and *funestus* (*minimus*) as vectors, supposedly on epidemiological evidence. What influence the work of Banks, Walker, and Barber had on their conclusion is not known. The only Philippine record of mosquito dissections for natural malarial infection was made by one of them (Tiedeman) on 360 negative *A. subpictus* Grassi, but none on their incriminated species. Only one *A. maculatus* Theobald, an important carrier in Malaya, was dissected in 1927.

Mosquito catches were carried on during the past two years in eight different camps on the water-project line, San Francisco del Monte and Novaliches, two "barrios," distant and unconnected with the project (see fig. 1). San Francisco del Monte is a prolific fresh-water *ludlowi* district. Table 2 shows blood surveys in the different places observed. In San Francisco del Monte, almost all of the *funestus* were caught in the human-baited trap operated from September, 1928, while the other species were caught on cows or water buffaloes. In South Portal, the trap has been used exclusively since March, 1928 (Plate 1, fig. 1). The trap is a small, wire-screened house, 2.5 by 2.5 by 2.5 meters, provided with a wire-screen ceiling and four doors. The catcher, with flashlight, catches between 7 and 10 p. m. He sleeps in the trap under a mosquito net. The doors are closed at 4 a. m., and he catches the trapped mosquitoes in the morning. In North Portal, a portable trap (Plate 1, fig. 2) has been used since September, 1928, while in Tungkong Manga, another portable trap (Plate 1, fig. 3) has been in use since June, 1929, and three traps attached to the field laboratory have been used since September of the same year. In the other stations mosquitoes were caught outside the houses and on animals.

⁵ Manalang, C., Philip. Journ. Sci. 37 (1928) 123.

⁶ Banks, Philip. Journ. Sci. § B 3 (1908) 335.

⁷ Philip. Journ. Sci. § B 9 (1914) 381; § B 10 (1915) 177.

⁸ Journ. Prev. Med. 3 (1927).

⁹ Ann. Report Philip. Health Service (1925).

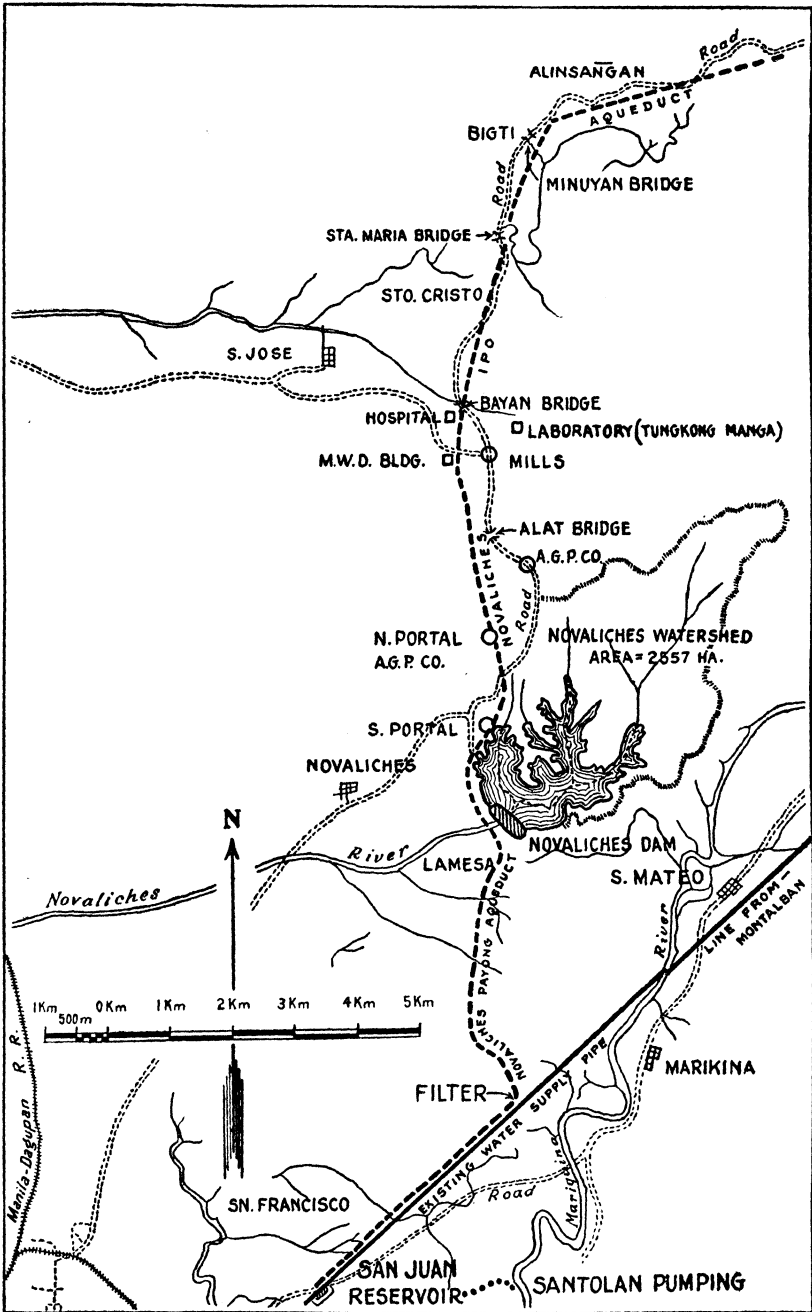


FIG. 1. The Novaliches water project.

They were caught regularly and brought to Manila daily except on Sundays and holidays. The dead mosquitoes were dissected at once, and those living were transferred into wide-mouthed bottles stoppered with a pledget of cotton saturated with water or dilute glucose water and kept in an ice box at automatically regulated temperature between 23 and 25° C. This treatment was found necessary to keep engorged mosquitoes alive long enough for positive blood meals to develop into oöcysts. Beginning September 1, 1929, all the mosquitoes were examined in the field laboratory at Tungkong Manga. Methods used for preserving malarial specimens taken from the mosquito have already been published¹⁰ with microphotographs. Photographic proofs of natural malaria infection in any species is believed very essential not only for future reference but in order that it may save useless and costly attempts at mosquito control. Fear of *ludlowi* and attempts against this species in Davao fishponds on the strength of Banks' findings and supported by the incriminations of later investigators form an excellent example. Tables 3 and 4 show the dissections in 1928 and 1929, respectively.

COMMENTS

1. Tables 1 and 2 show that each species was numerically well represented.

2. Positive mosquitoes (*funestus*) were found in five of seven places in 1928 and in three of seven places in 1929.

3. All the positives were found in *A. funestus* excepting one heavily infected stomach of *A. vagus* Donitz from San Francisco del Monte, in June, 1929. In fifteen *funestus* both stomach and salivary glands were infected.

4. La Mesa supplied 429 *funestus* in a total catch of 521 in 1928 with 14 positives. South Portal for 1928 and 1929 supplied 7,025 *funestus* in a total catch of 7,505 with 210 positives. The prevalence of *funestus* in both these stations (over 92 per cent) showed them to be typically *funestus* districts.¹¹

5. In San Francisco del Monte the *funestus* catch was about 4 per cent of the total (594 of 14,157) with 2 positives, while in Tungkong Manga and North Portal, they constituted 29 and 30 per cent, respectively, of the total catches with 7 positives in the former and 25 positives in the latter.

6. A total of 7,036 *ludlowi* from San Francisco del Monte (the *ludlowi* district) in a total catch of 14,011; 2,146 from

¹⁰ Manalang, C., Philip. Journ. Sci. 42 (1930) 481.

¹¹ Even after differentiation of *aconitus* var. *filipinæ*.

TABLE 2.—Blood surveys in the different places observed.

Place.	Surveys.		Number examined.	Types of infection.				Positive.	
	Number.	Date.		<i>P. vivax.</i>	<i>P. malariae.</i>	<i>P. falciparum.</i>	Mixed.	Total.	Per cent.
1. La Mesa.....	1	Dec., 1926	332	3	0	5	0	8	2.41
Do.....	2	Feb., 1927	80	8	0	9	1	18	22.50
Do.....	3	----- 1927	45	18	0	5	1	24	* 53.33
Do.....	4	June, 1928	300	5	0	12	0	17	5.67
Do.....	5	Apr., 1930	28	1	0	0	0	1	3.40
2. South Portal.....	1	Sept., 1928	40	1	0	2	0	3	7.50
Do.....	2	Sept., 1929	91	11	0	7	0	18	19.78
Do.....	3	Apr., 1930	130	1	0	0	0	1	0.70
3. North Portal.....	1	June, 1928	43	5	0	2	0	7	16.27
Do.....	2	Sept., 1928	49	11	0	4	0	15	30.61
Do.....	3	Jan., 1929	86	4	0	3	1	8	9.30
4. Atlantic, Gulf, and Pacific Co.....	1	June, 1928	130	13	0	9	4	26	20.00
5. Tungkong Manga.....	1	Jan., 1927	56	0	0	0	0	0	.00
Do.....	2	Aug., 1929	73	18	0	8	0	26	35.60
6. San Francisco del Monte.....	1	Dec., 1927	23	6	0	1	0	7	^b 30.40
Do.....	2	Feb., 1928	78	12	0	2	0	14	^b 18.00
7. Novaliches.....	1	----- 1927	182	3	0	6	0	9	^a 4.94
Do.....	2	Dec., 1928	108	3	1	2	0	6	^b 5.50
8. Bigti (including Minuyan).....	1	Oct., 1929	200	10	0	2	1	13	6.50
Bigti.....	2	Nov., 1929	51	1	0	0	0	1	1.96
9. Santo Cristo.....	1	Jan., 1927	180	0	0	1	0	1	0.60
Do.....	2	Oct., 1929	59	10	0	0	2	12	20.34
10. Alinsangan.....									

^a Children, splenomegaly 84.44 per cent.^b Children.^c Children, splenomegaly 8.24 per cent.

TABLE 3.—*Mosquitoes dissected in 1928.*

Place.	<i>A. funestus (minimus).</i>				<i>A. tessellatus.</i>	<i>A. hyrcanus (st-nensis).</i>	<i>A. barbivrositis.</i>	<i>A. rossi.*</i>	<i>A. karwari.</i>	<i>A. philippinensis.</i>	<i>A. fuliginosus.</i>	<i>A. ludlowi.</i>	<i>A. kochi.</i>	<i>A. maculatus.</i>	Total.
	Total.	Positive.		Per cent.											
		Stom-ach.	Salivary glands.												
South Portal.....	5,765	107	83	3.31	10	6	83	66	18	40	8	9	---	4	6,010
San Francisco.....	297	2	---	.67	55	331	171	2,390	51	1,218	155	2,520	49	7	7,244
North Portal.....	2,171	17	4	.79	898	1,749	259	835	397	922	538	178	112	23	8,082
La Mesa.....	429	7	7	3.26	---	---	12	22	1	22	32	2	---	1	521
Novaliches.....	585	---	---	---	1	---	71	846	1	8	18	19	15	3	1,567
Atlantic, Gulf, and Pacific Co.....	359	10	3	3.60	---	---	---	1	---	---	---	---	---	---	360
Tungkong Manga.....	273	---	---	---	14	5	6	22	4	2	4	28	6	1	365
Total.....	9,879	143	97	2.50	978	2,091	602	4,182	472	2,212	755	2,756	182	39	24,149

* *Anopheles vagus*, mostly; *subpictus*, few.

TABLE 4.—*Mosquitoes dissected in 1929.*

Place.	<i>A. funestus (minimus).</i>				<i>A. aco.^a</i>	<i>A. tessellatus.</i>	<i>A. sinensis.</i>	<i>A. barbitrostris.</i>	<i>A. roosei.^b</i>	<i>A. karwari.</i>	<i>A. philippinensis.</i>	<i>A. fultoniensis.</i>	<i>A. ludlowi.</i>	<i>A. kochi.</i>	<i>A. maculatus.</i>	Total dissected.
	Total.	Positive stomachs.	Positive salivary glands.	Per cent. infection.												
South Portal.....	1,260	12	8	1.6	---	6	37	13	69	4	67	9	8	---	23	1,496
San Francisco.....	297	0	0	0	---	7	79	61	1,863	10	8	20	4,516	7	45	6,913
North Portal.....	3,020	2	2	0.13	---	474	644	327	2,466	137	61	189	979	75	358	8,730
Bigti.....	191	0	0	0	---	---	345	66	755	3	38	13	10	48	6	1,485
Tungkong Manga.....	4,762	4	3	0.14	4	142	689	534	5,337	154	849	249	2,118	356	1,346	17,140
Santo Cristo.....	266	0	0	0	19	44	285	84	2,360	25	418	210	893	86	191	4,881
Alinsangan.....	41	0	0	0	---	2	23	9	178	2	4	---	---	10	---	269
Total.....	9,837	18	13	-----	24	684	2,102	1,094	13,628	335	1,445	690	8,524	582	1,969	40,914

^a Separate identification from *funestus* toward the end of the year.^b *Anopheles vagus* + *subpictus*, one positive stomach in June (San Francisco).

Tungkong Manga in a total of 17,140; 1,157 from North Portal in a total catch of 16,812, or 10,339 *ludlowi* from three places, were all found negative. Altogether 11,280 *ludlowi* were dissected during 1928 and 1929.¹² Of 594 *funestus* from San Francisco del Monte, 5,035 from Tungkong Manga, and 5,191 from North Portal, or a total of 10,820 *funestus* (about the same as the number of *ludlowi* from these places), 34 positives were found. Surveys of coastal places where brackish-water *ludlowi* is abundant have so far revealed no indigenous malaria. Coastal towns may have malaria, but they are invariably at the foot of hills or mountains, suitable for *funestus* breeding.

7. In 1929, Tungkong Manga and North Portal supplied 1,346 and 358 *A. maculatus*, respectively. Altogether 2,008 negative *maculatus*¹³ were dissected from different places, in five of which *funestus* was found infected.

CONCLUSIONS

Two years of dissection of anophelines caught in ten places shows conclusively that of the twelve species numerically well represented in about 65,000 mosquitoes *A. funestus* (*minimus*), the same vector found in 1927, is the natural vector of malaria in the Philippines.

It may still be possible to demonstrate that under natural conditions other anopheline species may transmit malaria, but the topography and mosquito fauna of the places studied are so typical of the many known malarious regions that such would be exceptional.¹⁵

¹² Dissections in 1930, January to July, 2,485.

¹³ Dissections of 1930, January to July, 962.

¹⁵ Of the anopheline mosquitoes captured in a portable trap (large mosquito net) set in a room with several known malaria cases at the Ipo Gold Mine camp, Bulacan, during the first three months of 1931, three with oöcysts in the stomach and one with sporozoites in the glands were found among eighty-seven *A. funestus*; among thirty-eight *A. maculatus*, two had oöcysts only in the stomach and one had both this organ and the glands infected. All blood-engorged mosquitoes were kept for several days until death in a humid chamber.

ILLUSTRATIONS

PLATE 1

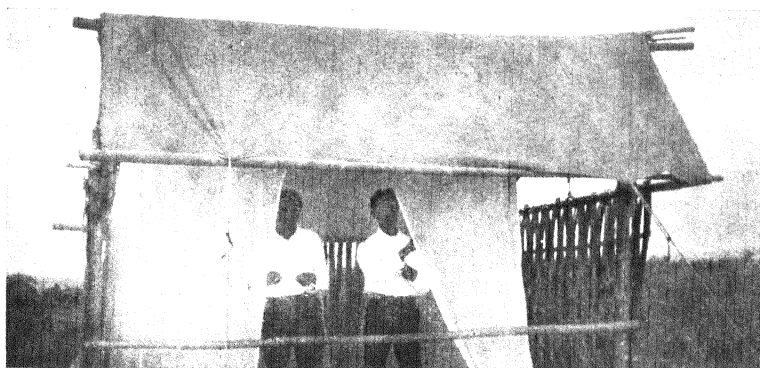
- FIG. 1. Mosquito trap at South Portal.
2. Portable trap at North Portal.
3. Another type of portable trap, at Tungkong Manga.

TEXT FIGURE

- FIG. 1. Map of the Novaliches water project.



1



2



3

THE ETHER-INSOLUBLE LEAD SALT OF LUMBANG OIL ¹

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Several investigations ² have been reported on lumbang oil. The oil has been found to consist mainly of the glycerides of oleic, linolic, and linolenic acids. The glycerides of certain solid acids are present in a small extent. Oxyacids have been detected that presumably are not original in the oil but have been formed by the action of atmospheric oxygen on the glycerides of unsaturated acids. The solid acids of lumbang oil and the oxyacid bodies formed in the oil have not been studied, though their presence has been mentioned in previous works.

Though several papers have been reported on lumbang oil, it is significant to note that there has been no attempt to identify the solid constituent of the oil. It seemed interesting to study the ether-insoluble lead salt of lumbang oil as it might lead to the discovery of new solid acids or solid acids already known. It is the purpose of this article to present the data and observations obtained in this study and to discuss their significance in the identification of a solid acid found in lumbang oil.

EXPERIMENTAL

Material used.—The lumbang (candlenut) oil used in this investigation was the remainder of the material which the writer used in his unsuccessful work on the preparation of α -bromolinolic acid tetrabromide.

¹Contribution from the research laboratory chemistry department, University of the Philippines. This work was begun in the organic laboratory of the Bureau of Science.

²Aguilar, R. H., *Philipp. Journ. Sci.* § A 12 (1917) 235; 14 (1919) 275; Brill and Agcaoili, *Philipp. Journ. Sci.* § A 10 (1915) 111; Richmond and del Rosario, *Philipp. Journ. Sci.* § A 2 (1907) 439; Welcot and Thompson, *Press Bull. Hawaii Agr. Exp. Station* 39 (1913); West and Montes, *Philipp. Journ. Sci.* 18 (1921); West and Gonzaga, *Philipp. Journ. Sci.* 23 (1923) 277; West and de Leon, *Philipp. Journ. Sci.* 24 (1924) 123; West and Smith, *Philipp. Journ. Sci.* 32 (1927) 297; West and Santiago, *Philipp. Journ. Sci.* 32 (1927) 41; West and Cruz, *Philipp. Journ. Sci.* 42 (1930) 251.

To eliminate the possible influence of oxyacids upon the observations recorded in this paper, the following experiments were undertaken.

Oxyacids are insoluble in petroleum ether while the solid acids and unsaturated acids are soluble in this solvent. It is, therefore, not difficult to test the presence of oxyacids in the solid acid constituent of lumbang oil. A known amount of the solid acids was dissolved in petroleum ether. No portion remained undissolved. It was passed through a filter paper into a tared small beaker. There was no residue left in the paper. The solvent was evaporated and the residue was put to dry for an hour in an electric oven maintained at 100° C. The starting amount was recovered. Thus it is shown that no oxyacids contaminated the solid acids used in this work.

It is interesting to note that the oxyacids were characterized by West,³ as precipitating from petroleum ether solution. Starting with 100 grams of oil the writer passed air through it at such a rate that the oil was kept stirred. The oil was hydrolyzed and the free acid was extracted with ether and dried. The solvent was evaporated and the dried free acids were dissolved in petroleum ether. The solution was set aside to clear up. Drops of brown colored oil were found to have separated and stuck to the wall of the flask. The clear solution was decanted and the drops of brown oil were washed with the same solvent. This brown oil is undoubtedly the same substance which West characterized as precipitating from petroleum ether solution. The amount of oxyacids obtained from 100 grams of lumbang oil blown with air for thirty-six hours did not exceed 0.4 per cent. These oxyacid bodies were found to dissolve in alcohol and ether. Dilute alkali solution reacted with them. The lead salts of these oxyacids are brown in color and do not melt even at the maximum temperature reached by the sulphuric acid bath. The free oxyacids are reddish brown in color which is believed by the writer to give rise to the color of the oil containing unsaturated glycerides. The oxyacids, when freed of solvent molecules, assume a resinlike mass but do not become solid after an exposure of several days.

From the above observations it appears that the starting material of this work did not contain oxyacid bodies to the extent of 0.4 per cent. The absence of oxyacids in the solid acids has been shown. It appears that they were eliminated in the course of purification of the lead salts and of the free solid acids.

³ Philip. Journ. Sci. 42 (1930) 252.

Preparation of the ether-insoluble lead salt of lumbang oil.—

In this work the procedure⁴ adopted to prepare this compound is identical with the method usually followed by oil investigators in separating the solid acid constituents of an oil from its unsaturated acids.

Five hundred cubic centimeters of lumbang oil was treated with 100 grams of potassium hydroxide dissolved first in 50 cubic centimeters of water to facilitate its solution with 500 cubic centimeters of aldehyde-free alcohol. The solution was digested on the steam bath for six hours, in a 2-liter round-bottomed flask fitted with a Liebig condenser. After digestion the solution was made neutral with acetic acid. The greater portion of the alcohol was then distilled off. In the meantime a hot solution of the required amount of lead acetate was made up and filtered. The hot lead acetate solution was added to the hot potassium salt of lumbang oil, shaking the reaction flask continuously while adding. More hot water was added. It was allowed to cool and the aqueous solution was decanted. The sticky lead salt was again washed with hot water and cooled before pouring off the aqueous solution. The washing was freed of water as much as possible. Ether was added to it and warmed gently on the water bath. This dissolved the salts of the unsaturated acids. The flask was set aside in a refrigerator over night, and the next morning it was filtered by gentle suction to separate the ether-insoluble lead salt. The product of first filtration, which was rather sticky, was again treated with ether. It was cooled and filtered. The lead salt was washed further with ether.

One gram of the above ether-insoluble lead salt was digested with ether and cooled. This was repeated until it was white and lost all its stickiness. It was dried in a calcium chloride desiccator for two days. It was found to melt at 104.5° to 105.5°.⁵ The salt was analyzed for lead as sulphate.

Analysis:

	Found Pb. Per cent.
0.1515 gram salt gave 0.0210 gram of dry PbSO ₄	27.87
0.0526 gram salt gave 0.0214 gram of dry PbSO ₄	27.79

⁴Gusserow, Liebig's Ann. 27 (1928) 153; Varentrapp, Liebig's Ann. 35 (1840) 197; Baughman and Jamieson, Journ. Am. Chem. Soc. 42 (1920) 152.

⁵Gerard, Ann. 27 (1892) 560, prepared the lead salt of daturic acid and reported the compound as melting at 104° to 105° and to be slightly soluble in hot alcohol.

Free solid acid and fractional crystallization of its barium salt.—The rest of the ether-insoluble lead salt obtained above was digested with excess dilute hydrochloric acid solution for an hour on the steam bath. An oil separated that solidified when the contents of the flask were cooled. The solid was extracted with ether and the ether solution was passed through a filter. The solvent was evaporated. The residue was found to melt at 54.5° to 55.5° . It was crystallized from alcohol; short white needle crystals were obtained that were found to melt at 57.5° .⁶

About 3 grams of the crystallized substance was made into its barium salt and fractionally crystallized according to the procedure adopted by Gerard. The first crop of crystals was crystallized twice from alcohol and then hydrolyzed with dilute hydrochloric acid to obtain the free acid. After crystallizing from alcohol, short needle crystals melting at 57.5° , as formerly observed, were obtained.

The neutralization equivalent of the free solid acid was determined. With 0.2 gram of the acid dissolved in neutral aldehyde free alcohol 7.4 cubic centimeters of 0.1 N sodium hydroxide ($F = 1.0017$), using phenolphthalein as an indicator, was used. The neutralization equivalent calculated from the experimental data is 269.81.⁷

Three months later, another determination was taken; 0.2 gram of the acid, dissolved in neutral alcohol, used 6.50 cubic centimeters of 0.1 N sodium hydroxide ($F = 1.1377$), giving a

⁶ Gerard, Ann. 26 (1892) 555, isolated daturic acid from the oil of the seeds of *Datura stramonium* and reported it as crystallizing into white needle crystals that melt at 55° . Kreis and Hafner, Ber. 36 (1903) 2770, isolated daturic acid from the fat of the hog and found it to melt at 55° to 56° . Holde and Stange, Ber. 34 (1901) 2402, 38 (1905) 1245, isolated daturic acid from olive oil and found it to melt at 54° to 57° . Nordlinger, Ber. 25 (1892) 578, reported 57° as the melting point of an acid that he claimed identical with Gerard's daturic acid. Meyer and Klimont, M. 36 (1915) 28, obtained daturic acid, melting point 56.5° to 57.5° , from horse fat. Meyer and Eckert, M 31 (1910) 1227, obtained daturic acid from the oil of coffee beans and reported the acid as melting at 57° . Meyer, Klimont, and Meisl, M 35 (1914) 1115, obtained heptadecylic acid from horse fat and reported it as melting at 57° to 57.5° . Meyer and Beer, M 33 (1912) 311, repeated the work of Gerard on the oil of the seeds of *Datura stramonium*. They reported daturic acid as melting at 59° to 59.5° and proved it identical with margaric acid. This work proved beyond doubt that daturic acid is a true acid.

⁷ The neutralization equivalent of daturic acid, as given in Mullikan's Identification of Pure Organic Compounds 1: 54, is 270.

neutralization value of 270.45, which agrees very closely with the first figure. Using the mean as the molecular weight of the free acid, the calculated per cent of lead in the salt is 27.79, which agrees very closely with the analytical figures given above. The fatty acid that gives the above molecular weight is heptadecylic acid.

Analysis: ^s

5.313 mg. Subst. gave 14.730 mg. CO ₂ and 5.964 mg. H ₂ O.	Found C. Per cent.
	75.61
Calculated for C ₁₇ H ₃₄ O ₂ : C, 75.6 per cent; H, 12.6 per cent.	Found H. Per cent.
	12.56

Molecular-weight determination by the Rast method.—Depression observed in the melting point of camphor by dissolving 3.87 milligrams of the solid acid in 24.504 milligrams camphor was 23°. A micro balance was used in weighing substances. The molecular weight calculated from these data is 275.1. Another experiment using the ordinary analytical balance was made. Observed depression in the melting point of camphor by dissolving 7.9 milligrams of the free acid in 69.5 milligrams of camphor was 16.5°. The molecular weight obtained from these results was 276.6. The figures are quite close and are comparable with the figure obtained for the neutralization equivalent of the acid.

To show the identity of the solid obtained from lumbang oil, several salts were prepared.

Lithium salt.—One gram of the free acid was treated with an alcoholic solution of the equivalent amount of lithium acetate prepared from lithium carbonate and acetic acid. The acid salt was precipitated from the hot alcoholic solution. It was filtered by suction and washed with hot 95 per cent alcohol. The dried salt melted at 220°.

Analysis:

0.1 gram salt gave 0.0195 gram dry Li ₂ SO ₄ .	Found Li. Per cent.
Calculated for LiC ₁₆ H ₃₃ CO ₂	2.46
	2.51

*Sodium salt.*⁹—One gram of the free solid acid dissolved in alcohol was treated with an alcoholic solution of the equivalent

^s The writer is kindly indebted to Prof. A. Santos, School of Pharmacy, University of the Philippines, for this micro-analysis.

⁹ Gerard, Ann. 27 (1892) 557, prepared the sodium acid salt and the neutral salt. He reported the neutral salt coming down from the solution as a gelatinous mass and that crystallization was difficult. The acid salt was found by analysis to contain one portion of sodium to two of the acid.

amount of sodium hydroxide. The salt did not precipitate from the hot alcoholic solution. When it was cooled rapidly the whole solution gelatinized. When cooled gently the salt deposited as a white precipitate. It was filtered by suction and washed with dilute alcohol. The dried salt was found to soften at 105° , became opaque liquid at 115° , and was transparent at 220° .

Analysis:

	Found Na. Per cent.
0.2 gram salt gave 0.0255 gram dry Na_2SO_4	4.13
Calculated for $\text{NaO}_2\text{C}_{17}\text{H}_{22}\cdot\text{C}_{17}\text{H}_{14}\text{O}_2$	4.096

*Potassium salt.*¹⁰—This compound was prepared in the same way as the sodium salt and behaved like it. It is soluble in hot ethyl alcohol. It gelatinizes when its alcoholic solution is rapidly cooled. When cooled slowly, it comes down as a white precipitate. The dry salt softens at 110° ; becomes an opaque liquid at 135° , and becomes a clear liquid at 138° .

Analysis:

	Found K. Per cent.
0.2 gram of salt gave 0.300 gram of dry K_2SO_4	6.75
Calculated for $\text{KO}_2\text{C}_{17}\text{H}_{22}\cdot\text{C}_{17}\text{H}_{14}\text{O}_2$	6.77

Rubidium salt.—This salt was prepared similarly to the above salts by treating 1 gram of the free solid acid dissolved in alcohol with the equivalent amount of rubidium acetate dissolved in the same solvent. Rubidium acetate was prepared in the laboratory by the interaction of rubidium bromide and silver acetate prepared from the action of acetic acid upon silver carbonate, which was obtained by the action of sodium carbonate upon silver nitrate solution. The rubidium salt was precipitated as a white solid when its alcoholic solution was gently cooled. The precipitate was filtered by suction and washed several times with 95 per cent alcohol. The dry salt was found to melt sharply at 120° .

Analysis:

	Found Rb. Per cent.
0.1 gram salt gave 0.0215 gram of dry Rb_2SO_4	13.76
Calculated for $\text{RbO}_2\text{C}_{17}\text{H}_{22}\cdot\text{C}_{17}\text{H}_{14}\text{O}_2$	13.67

¹⁰ Gerard, Ann. 27 (1892) 556, prepared the potassium salt and he reported having obtained a neutral salt and an acid salt. The neutral salt of potassium behaves like the neutral salt of sodium. By analysis, the potassium acid salt is made up of one portion of the metal to two of the acid.

*Zinc salt.*¹¹—One gram of the potassium salt of the acid as prepared above was dissolved in warm alcohol and this was treated with the equivalent amount of zinc chloride dissolved in the same solvent. This zinc salt of the acid precipitated from the hot alcoholic solution. It was filtered by suction and washed with warm 95 per cent alcohol. The salt was dried at 100°.

Analysis:

	Found Zn. Per cent.
0.1 gram of salt gave 0.0262 gram of dry ZnSO_4	10.61
Calculated for $\text{Zn}(\text{C}_{17}\text{H}_{33}\text{O}_2)_2$	10.82

Calcium salt.—This compound was prepared similarly to the zinc salt of the acid. A white precipitate came down from the hot alcoholic solution of the reactants. It was filtered by suction and washed with hot 95 per cent alcohol. The salt was dried at 100°. It was found to melt at 182° to 183°.

Analysis:

	Found Ca. Per cent.
0.1 gram of salt gave 0.0220 gram of dry CaSO_4	6.50
Calculated for $\text{Ca}(\text{C}_{17}\text{H}_{33}\text{O}_2)_2$	6.93

Mercuric salt.—This compound was prepared in the same way as were the salts of the bivalent metals recorded above. The salt crystallized into short needle crystals from alcohol. It was filtered by suction and washed well with 95 per cent alcohol. The dry crystals were found to melt at 113° and solidified completely at 110°. Because the sulphate of mercury volatilizes, the free acid was determined from a weighed amount of the salt.

Analysis:

	Found $\text{FC}_{17}\text{H}_{34}\text{O}_2$. Per cent.
0.2045 gram of salt gave 0.1491 gram of dry acid	72.91
	Found $\text{C}_{17}\text{H}_{33}\text{O}_2$. Per cent.
Calculated for $\text{Hg}(\text{C}_{17}\text{H}_{33}\text{O}_2)_2$	73.13

Strontium salt.—One gram of the free acid was treated with an equivalent amount of strontium acetate prepared from strontium carbonate and acetic acid, using alcohol as a reaction medium. The salt precipitated as a white solid from the hot alcoholic solution. It was filtered by suction and washed well with hot alcohol. The dry compound was found to melt above 265°.

¹¹ Gerard, Ann. 27 (1892) 559, reported having prepared the zinc salt of daturic acid.

Analysis:

	Found Sr. Per cent.
0.1 gram of salt gave 0.0261 gram of dry SrSO_4	12.45
Calculated for $\text{Sr}(\text{C}_{17}\text{H}_{33}\text{O}_2)_2 \cdot 4\text{H}_2\text{O}$	12.55

Thallium salt.—This compound was prepared in the same way as the above strontium salt. The salt did not precipitate from hot alcoholic solution, but when it was cooled by running water a white solid came down. The precipitate was filtered, washed, and dried at 100° .

Analysis:

	Found Tl. Per cent.
0.1 gram of salt gave 0.0460 gram of dry Tl_2SO_4	37.21
Calculated for $\text{C}_{17}\text{H}_{33}\text{O}_2\text{Tl} \cdot 4\text{H}_2\text{O}$	37.41

Uranyl salt.—One gram of the free acid was dissolved in warm alcohol, and this was treated with a hot alcoholic solution of the equivalent amount of uranyl acetate. A yellowish solid precipitated. It was dried at 100° . It was found to soften at 146° and to melt at 150° .

Analysis:

	Found UO_2 . Per cent.
0.1 gram of salt gave 0.0415 gram of dry UO_2SO_4	30.62
Calculated for $\text{UO}_2(\text{C}_{17}\text{H}_{33}\text{O}_2)_2 \cdot 4\text{H}_2\text{O}$	30.68

Cadmium salt.—This compound was prepared in the same way as the strontium salt. It was precipitated from hot alcohol. The solid was filtered and washed with hot alcohol. The dry salt was found to melt at 104.5° to 105.5° .

Analysis:

	Found Cd. Per cent.
0.1 gram of salt gave 0.0283 gram of dry CdSO_4	15.12
Calculated for $\text{Cd}(\text{C}_{17}\text{H}_{33}\text{O}_2)_2$	15.54

*Barium salt.*¹²—This salt was prepared like the preceding compound. A white fine powder was obtained after drying.

Analysis:

	Found Ba. Per cent.
0.1 gram of salt gave 0.0342 gram of dry BaSO_4	20.02
Calculated for $\text{Ba}(\text{C}_{17}\text{H}_{33}\text{O}_2)_2$	20.32

¹² Gerard, Ann. 27 (1892) 559, prepared the barium salt of daturic acid.

Methyl ester.—About 7 grams of the free acid was melted and to it was added the calculated amount of phosphorus trichloride ($\frac{1}{3}$ m). The mixture was digested very gently with a small flame. A yellowish sticky solid adhered to the wall of the flask, which was fitted with a ground-glass condenser. In about an hour the reaction was complete, and the liquid product was set aside to cool. It solidified in the flask. It was found to soften at 52° and completely liquefied at 60° .

About 2 grams of the acid chloride was treated with an excess of methyl alcohol. The solution was put in a warm place for one hour after which the liquid methyl ester that separated from the methyl alcohol was separated. Ether was added and the solution was washed with dilute sodium hydroxide and with distilled water. The ether solution was dried with sodium carbonate and filtered. The solvent was evaporated and a liquid residue was obtained that solidified when cooled with running water. The solid was found to melt at $30^{\circ 13}$ in a small capillary tube. It solidified completely at 28° , giving fine needle crystals.

For an hour 0.2055 gram of the ester was digested with an excess of alcoholic potash. The soap solution was treated with excess dilute hydrochloric acid solution and was digested for half an hour. The flask and its contents were cooled and the acid was extracted with ether and transferred to a small tared flask. The solvent was evaporated, and the residue was put in a 100° oven for an hour to dry. The residue was found to weigh 0.1954 gram.

Analysis:

	Found $C_{17}H_{34}O_2$.
	Per cent.
0.2055 gram of ester gave 0.1954 gram of dry acid	95.05
	Found $C_{16}H_{32}COOH$.
	Per cent.
Calculated for $C_{16}H_{32}CO_2CH_3$	95.06

The free acid obtained from the ester melted sharply at 57.5° .

Ketone from the solid acid.—Approximately 1 gram of the acid was distilled with about 0.2 gram of dry calcium oxide. The distilled compound was extracted with ether and washed with dilute sodium hydroxide and distilled water. The solvent was evaporated, and the residue was crystallized from alcohol.

¹³ Gerard, Ann. 27 (1892) 562, prepared the methyl ester of daturic acid and reported it as crystallizing into needles which melted at 30° and solidified at 28° . Meyer and Eckert, M, 31 (1910) 1227, prepared the methyl ester and reported it as melting at 30° .

Pearly scales were obtained which melted at 78° and crystallized at 75° to 76° .¹⁴ It is insoluble in water and cold alcohol but very soluble in hot alcohol and ether.

Determination of the solid acid constituent of lumbang oil.—The procedure adopted in determining the solid acid constituent of the oil is the same as the method used in preparing the ether insoluble lead salt described elsewhere in this paper with a more careful manipulation of the different steps so that the compounds were not unduly exposed to the oxidizing effect of the air. Before filtering the ether-insoluble lead salt, the ether solution was sufficiently cooled. The washing of the lead salt with previously cooled ether was carried out more thoroughly so that the salt obtained was perfectly white and had lost all its stickiness. That a pure salt was obtained was shown by the fact that the free solid acid obtained in two determinations melted sharply at 57.5° without any depression in melting point when mixed with the recrystallized acid obtained above. The free acid obtained in two experiments was dried for one hour at 100° before the final weight was taken.

Analysis:

	Found $C_{16}H_{33}CO_2H$. Per cent.
50 grams of lumbang oil gave 1.8935 grams of dry white acid	3.78
10 grams of lumbang oil gave 0.379 gram of dry white solid acid	3.79

The figures obtained in two determinations agree very closely. The content of solid acid in lumbang oil as found in this work is, therefore, 3.79 per cent.¹⁵

DISCUSSION

The analytical data obtained from the salts of the solid acid of lumbang oil showed that the substance is a heptadecylic acid. It was further pointed out that the acid has only one replaceable

¹⁴ Gerard, Ann. 27 (1892) 563, prepared a ketone from daturic acid by distilling the acid with dry calcium oxide. He reported it as crystallizing into shiny scales which melted at 75.5° to 76° .

¹⁵ In one of the researches reported by West, Philip. Journ. Sci. 18 (1921) 619, he mentioned solid acids being present in the oil to the extent of 2.68 per cent. He stated that this mixture of solid acids melted at 54° and that it had an iodine number of 18.05 (Hubl). In a recent paper by West and Cruz, Philip. Journ. Sci. 42 (1930) 251–57, the authors reported a lower percentage of the amount of solid acids which is only 2.02 per cent. They did not identify their solid acids.

hydrogen atom. The molecular weight obtained from the measurement of the neutralization equivalent is identical with the molecular weight of heptadecylic acid.

This heptadecylic acid shows properties identical with those of daturic acid. The methyl ester and ketone obtained from this acid show properties identical with the properties of the corresponding derivatives of daturic acid. The salts prepared in this work show properties identical with the properties of the salts of daturic acid which have been already reported in the chemical literature. It appears, therefore, that the heptadecylic acid isolated from the solid constituent of lumbang oil is daturic acid.

It has been stated elsewhere that this heptadecylic acid was obtained by fractional crystallization of its barium salt. Gerard has shown in his work that this is a practicable method and the experience obtained from this work supports this claim.

Comparing the salts of the monovalent alkali metals, a striking difference is noted. The lithium salt was precipitated from warm alcoholic solution, like the salts of the bivalent alkaline earth metals, while the salt of sodium, potassium, and rubidium were precipitated from cold alcoholic solution. Lithium was found to give only the neutral salt, while sodium, potassium, and rubidium gave both the acid and neutral salts. The neutral salts of sodium, potassium, and rubidium were observed to gelatinize. A small amount of these salts is sufficient to gelatinize a thousand times its own weight of alcohol.

The salts of the alkaline earth metals behave alike except that the strontium and cadmium salts have four molecules of combined water as calculated from analysis. The salt of thallium, like that of cadmium and strontium, shows four molecules of combined water; the uranyl salt also contains four molecules of combined water.

Two determinations of the amount of solid acids in lumbang oil gave 3.79 per cent. The acids obtained in these determinations were perfectly white, which shows the absence of deep brown red oxyacids. They were found to melt sharply at 57.5° , which indicates that pure substances had been prepared.

SUMMARY

The ether-insoluble lead salt obtained from lumbang oil was found to be the salt of heptadecylic acid. The heptadecylic acid obtained from the lead salt appears to be identical with daturic acid.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM THE PHILIPPINES (DIPTERA), VIII *

By CHARLES P. ALEXANDER

Of Amherst, Massachusetts

THREE PLATES

All species of crane flies discussed in the present paper are from central and northern Luzon, where they were collected in Mountain and Rizal Provinces, by Duyag; in Laguna Province, by McGregor; and in Cagayan, Mountain, and Pampanga Provinces, by Rivera. As before, I am greatly indebted to Mr. McGregor and his coworkers for their continued interest in collecting and saving these fragile flies from many parts of the Philippines. I am again indebted to Mr. McGregor for the privilege of retaining the material herein considered.

Our knowledge of the Philippine crane flies is now such that it seems advisable to give a list of the generic and subgeneric groups so far discovered in the Islands. All of the groups listed below have been taken in Luzon, where especial attention has been devoted to the Tipulidæ. Names marked with an asterisk (*) indicate groups that have been taken in Luzon but not in Formosa. Groups marked with an obelisk (†) have not been recorded hitherto from the Philippines.

*Generic and subgeneric groups of Tipulidæ known to occur in the
Philippine Islands.*

Tipulinæ.

Tipulini.

Pselliophora O. S.

Ctenacroscelis End.

Tipula.

Tipula Linn.

Acutipula Alex.

Nephrotoma Meig.

Tipulodina End.

* *Macgregoromyia* Alex.

* *Scamboneura* O. S.

Dolichopeza.

Nesopeza Alex.

* *Megistocera* Wied.

* Contribution from the Entomological Laboratory, Massachusetts
Agricultural College.

Cylindrotominæ.

* *Stibadocera* Brun.

Limoniinæ.

Limoniini.

Limonia.*Limonia* Meig.*Libnotes* Westw.† *Discobola* O. S.*Dicranomyia* Steph.*Geranomyia* Hal.† *Rhipidia* Meig.*† *Doaneomyia* Alex.*Thrypticomys* Skuse.*Pseudoglochina* Alex.*Goniodineura* v. d. W.*Alexandriaria* Garr.*Euglochina* Alex.*Helius*.*Helius* St. Farg.*Eurhamphidia* Alex.*Antocha*.* *Orimargula* Mik.*Orimarga* O. S.

Lechriini.

* *Lechria* Skuse.

Hexatomini.

Epiphragma O. S.*Pseudolimnophila* Alex.† *Pilaria* Sint.*Limnophila*.*Limnophila* Macq.† *Ephelia* Schin.† *Dicranophragma* O. S.† *Adelphomyia* Bergr.*Eriocera* Macq.*Elephantomyia*.*Elephantomyodes* Alex.

Eriopterini.

Conosia v. d. W.*Trentepohlia*.* *Paramongoma* Brun.*Mongoma* Westw.*Trentepohlia* Big.*Toxorhina*.*Ceratocheilus* Wesché.*Toxorhina* Lw.*Gonomyia*.*Ptilostena* Bergr.*Lipophleps* Bergr.

Limoniinæ—Continued.

Eriopterini—Continued.

Gnophomyia O. S.

Teucholabis.

Teucholabis O. S.

Gymnastes Brun.

Cryptolabis.

Baeoura Alex.

Erioptera.

Erioptera Meig.

Molophilus Curt.

Styringomyia Lw.

TIPULINÆ

TIPULODINA PAMPANGENSIS sp. nov.

General coloration obscure yellow, marked with black; pleura yellow, with small dark spots; legs black, ringed with white; all basitarsi black, the tips conspicuously snowy white; wings light yellow, with a brown pattern; no dark area in cell M; Rs very short, less than R_{2+3} ; R_3 long and extended.

Female.—Length, about 26 millimeters; wing, 18.5.

Frontal prolongation of head ochereous above, brownish black laterally; palpi brownish yellow. Antennæ with the scapal segments ochereous; flagellum broken. Head brownish gray, the frons yellow.

Pronotum brownish black above, yellow laterally. Mesonotal præscutum obscure yellow, almost covered by four blackish stripes that are narrowly margined with dull black; lateral margins of sclerite more pruinose; posterior sclerites of mesonotum dull black, the sides of the postnotum paler. Pleura yellow, with small blackish spots, including one on the otherwise yellow dorsopleural membrane, an area above the fore coxa, another above the meron, and an elongate band on the pleurotergite. Halteres black. Legs with the coxæ yellow, the posterior coxæ more grayish behind; trochanters yellow, marked with darker; fore femora brown, with a broad whitish subterminal ring; fore tibiæ black, with a broad white subterminal ring that is a little greater than the blackened tip; middle femora brown, the tips brownish black; middle tibiæ about as on forelegs; posterior femora brown, the tips blackened; posterior tibiæ black, with two white rings; all basitarsi black, the apical fourth or fifth snowy white; segments two to four white, the terminal segment blackened; setæ of the white rings very small and delicate, snowy white. Wings (fig. 1) with the ground color light yellow, the

brown pattern about as in allied forms; no darkening in cell M. Venation: Rs very short, less than R_{2+3} ; R_s long and extended.

Abdominal tergites reddish brown, blackened medially; on the outer segments the areas widened out so as to restrict the ground color to basolateral triangles, the caudal margins narrowly pale; sternites paler.

LUZON, Pampanga Province, Mount Arayat, October, 1929 (*Rivera*); holotype, female.

Tipulodina pampangensis is distinct from the other described Philippine species in the yellow-tinted wings, without darkening in cell M and with the venational details quite different from *T. luzonica* Alexander. The latter species usually has the tips of the basitarsi similarly pale, but I have seen specimens that were apparently conspecific in which the basitarsi were entirely blackened.

Genus SCAMBONEURA Osten Sacken

Scamboneura OSTEN SACKEN, Berlin. Entomol. Zeitschr. 26, Heft 1 (1882) 95.

At this time I am describing as new three species of this genus and am further describing and illustrating the details of the male hypopygium of *Scamboneura unicolor* Bezzi and *S. plumbea* Alexander. The number of species now known from the Philippines is eleven and a new key to these forms is provided, to supersede the earlier one.¹

Key to the Philippine species of *Scamboneura* Osten Sacken.

1. Anterior cord transverse or subtransverse, Rs in approximate alignment with the remaining elements of the cord..... 2.
Anterior cord strongly bowed, Rs lying distad of the remaining elements of the cord 4.
2. Anterior cord subtransverse, cell R_s lying proximad of cell R_3 ; median præscutal stripe divided by a paler line.

S. subtransversa sp. nov.

- Anterior cord transverse, cell R_s lying proximad of cell R_3 ; when the præscutum is striped, the median vitta is entire 3.
3. Mesonotal præscutum and scutal lobes with plumbeous markings that are narrowly bordered by black..... *S. primaeva* Alexander.
Mesonotal præscutum yellowish, immaculate.... *S. primogenia* sp. nov.
 4. Thoracic dorsum strongly pruinose, never polished, the gray coloration forming a discal shield 5.
Thoracic dorsum not pruinose, either polished or opaque, the præscutal disk with separate stripes (except in *unicolor*)..... 7.

¹ Philip. Journ. Sci. 33 (1927) 293-294.

5. Thoracic dorsum and pleura uniformly plumbeous.

S. plumbea Alexander.

Thorax not uniformly plumbeous, at least the pleura variegated with pale and dark areas 6.

6. Pleura conspicuously striped with darker....*S. psarophanes* Alexander.

Pleura, especially the sternopleurite, not conspicuously striped with darker *S. banahaoensis* sp. nov.

7. Mesonotal præscutum with three stripes that are polished brown, slightly metallic, bordered by opaque black; pleura pale, distinctly variegated with darker *S. dotata* Osten Sacken.

Mesonotal præscutum without stripes of this nature; pleura uniformly pale 8.

8. General coloration of head and thorax yellow, immaculate.

S. unicolor Bezzi.

Either the præscutum or the head, or both, marked with darker.... 9.

9. Præscutal stripes polished; head unmarked except for an occipital area.

S. faceta Alexander.

Præscutal stripes opaque; occipital area sending a narrow dark vitta cephalad onto the vertex 10.

10. Præscutal stripes ill-defined to subobsolete; male hypopygium not conspicuously enlarged, the eighth sternite without long conspicuous setæ *S. vittivertex* Alexander.

Præscutal stripes distinct; male hypopygium enlarged, the eighth sternite with abundant long reddish setæ.

S. hirtisternata Alexander.

The three species first named, having the anterior cord of the wings transverse or nearly so, have all been discovered since the preparation of the former key (1927).

SCAMBONEURA SUBTRANSVERSA sp. nov.

General coloration yellow, the præscutum with three brown stripes, the median one divided by a brownish yellow vitta; vertex of head with a black median vitta; wings with the elements of the anterior cord in nearly transverse alignment, the inner end of cell R_5 lying slightly proximad of that of cell R_3 ; abdominal tergites yellow, each with a metallic area at near mid-length.

Male.—Length, about 11 millimeters; wing, 9.5.

Female.—Length, about 16 millimeters; wing, 11.5.

Frontal prolongation of head yellow, narrowly dark brown above; mouth parts, with the exception of the infuscated outer segments of the maxillary palpi, pale. Antennal scape yellow, the flagellum nearly uniformly blackened in male, only the outer end of the basal segment being pale; in the female the basal segment is chiefly yellow and the outer ends of the succeeding five or six segments are yellowish; antennæ of male more elon-

gate than that of female, the verticils much shorter than the segments in both sexes. Head with the posterior vertex, occiput, and postgenæ grayish brown, the anterior part of the head orange, with a conspicuous black median vitta extending virtually to the summit of the vertical tubercle.

Pronotum infuscated on cephalic portion, the narrow posterior median portion obscure yellow. Mesonotal præscutum pale yellow, with three shiny brown stripes, the short lateral stripes slightly more bronzy, entire or narrowly bordered by velvety brownish black; the larger wedge-shaped median area conspicuously divided by a brownish-yellow center that does not attain the suture behind; scutal lobes almost covered by extensive dark areas that are quite similar in color to the lateral præscutal stripes; scutellum more or less infuscated; postnotal mediotergite pale whitish yellow, with a $\perp$ -shaped brown pruinose marking. Pleura pale testaceous yellow, unmarked, somewhat more pruinose dorsally, clearer yellow ventrally. Halteres infuscated, the base of the stem narrowly pale. Legs with the coxæ and trochanters pale; femora yellow; tibiæ and tarsi passing into brown. Wings (fig. 2) tinged with yellow, the prearcular and costal regions deeper yellow; stigma very small, brown; veins black, C, Sc, R, and Cu more yellowish brown. Venation: Anterior cord almost transverse, the proximal end of cell R_5 lying slightly proximad of cell R_3 ; Rs in approximate alignment with the remainder of cord.

Abdominal tergites yellow, each with a metallic steel-gray or blue median area at near midlength of the segment, these becoming smaller behind and finally obsolete on the outer segments; extreme lateral margins of the segments darkened, interrupted at posterior margin of segment; sternites yellow; hypopygium yellow. Male hypopygium with the caudal margin of the ninth tergite (fig. 23) with a U-shaped notch, the ventral margins set with delicate setæ that pass into small blackened conical spines; sublateral arms on ventral surface terminating in four or five blackened teeth. Outer dististyle irregular in outline. Inner dististyle about as illustrated (fig. 24). Appendage of ninth sternite (fig. 25) narrow, liguliform, very gradually narrowed outwardly, the apex weakly bilobed, the surface of the appendage densely set with microscopic yellow spines that are longer and coarser at tips of lobes. Margins of ninth sternite adjoining the appendage with very long conspicuous yellow setæ. Caudal margin of eighth sternite (fig. 26) evenly rounded, at midwidth with a brush of short stiff black setæ.

LUZON, Rizal Province, Novaliches, June 27, 1929 (*Duyag*); holotype, male; allotype, female, June 28, 1929 (*Duyag*); Pangasinana Province, Mount Arayat, October, 1929 (*Rivera*); paratypes, 20 males and females.

SCAMBONEURA PRIMOGENIA sp. nov.

General coloration brownish yellow, the mesonotum unmarked; antennæ of male relatively short, if bent backward extending about to the root of the halteres; wings with Rs in alignment with the other elements of the anterior cord; male hypopygium with the appendage of the ninth sternite a simple slender lobe.

Male.—Length, about 13 millimeters; wing, 13.

Female.—Length, about 14 millimeters; wing, 12.5.

Frontal prolongation of head yellow, the nasus long and conspicuous; palpi pale yellow. Antennæ (male) relatively short, only a little longer than the palpi, if bent backward extending about to the root of the halteres; scape yellow, flagellum black. Head of male yellow, unmarked, of female with indications of a median brown vitta.

Mesonotum brownish yellow, subnitidous, without markings. Pleura somewhat clearer yellow. Halteres dark brown. Legs with the coxæ and trochanters yellow; femora obscure yellow, the outer portions more darkened; tibiæ and tarsi dark brown. Wings (fig. 3) whitish subhyaline; stigma small, brown; veins black, C, Sc, R, and Cu paler. Venation: Rs in alignment with the other elements of the anterior cord; R_{1+2} represented by a spur that is subequal to R_2 alone; R_3 gently arcuate.

Abdomen (male) brownish yellow, the basal tergites and the sternites clearer yellow; in female, abdominal tergites almost entirely deep blue-black, the bases and extreme caudal margins of the segments restrictedly paler. Male hypopygium with the ninth tergite (fig. 27) entirely pale above, the caudal margin with a deep V-shaped notch, the lateral lobes broadly rounded; ventral surface of tergite with a few scattered blackened spicules. Dististyles about as illustrated (fig. 28), the apical beak of the inner style stout and only slightly blackened. Appendage of ninth sternite (fig. 29) a long, slender lobe, appearing as a simple rod-shaped structure, the apex obtuse, the organ fringed with delicate setulæ. Gonapophyses as illustrated (fig. 30).

LUZON, Cagayan Province, Mount Tabuan, May, 1929 (*Rivera*); holotype, male; allotype, female; paratype, female.

Scamboneura primogenia is most closely allied to *S. primaeva* Alexander, differing most evidently in the unvariegated mesonotum. The male sex of *S. primaeva* is still unknown.

SCAMBONEURA BANAHAOENSIS sp. nov.

Most closely allied to *S. psarophanes* Alexander, differing in the details of coloration and structure of the male hypopygium: pleura not conspicuously variegated with darker.

Male.—Length, about 12 millimeters; wing, 11.

Female.—Length, about 16 millimeters; wing, 13.

Antennæ with the flagellum of male blackened, of the female with the tips of the basal segments narrowly pale to produce a weakly bicolorous appearance. Occiput and posterior portion of vertex gray, sending a broad black median vitta almost to the summit of the vertical tubercle, the mark much broader and more distinct than in *psarophanes*.

Præscutal stripes four in number, blackened, separated from one another by yellowish gray to clear gray pruinose interspaces; humeral and lateral portions of the præscutum obscure yellow. Pleura chiefly pale yellow, weakly pruinose but not conspicuously marked with darker, as in *psarophanes*. Legs with the coxæ and trochanters yellow, the cephalic face of the fore coxæ darkened; femora yellowish brown, the tibiæ and tarsi darker. Wings (fig. 4) a little narrower, the anterior cord slightly more bowed; vein and cell 2d A slightly shorter; macrotrichia of veins slightly longer and more conspicuous.

Abdomen with the tergites yellow, conspicuously trivittate with shiny black, the median stripe shiny, interrupted on the anterior ring of the segments and more narrowed on the posterior margin; lateral stripes narrow but continuous; sternites yellow; hypopygium chiefly yellow. Male hypopygium with the caudal margin of the tergite (fig. 31) with a narrow V-shaped notch, that is further produced into a compressed blade. Outer dististyle (fig. 32) narrowed to a slender obtuse lobe. Inner dististyle as illustrated (fig. 33). Appendage of ninth sternite (fig. 34) depressed, the caudal end emarginate, the surface covered with abundant pale yellow setæ that are longer and more conspicuous on the lateral lobes, these latter with a single powerful black seta on outer margin before apex. Caudal margin of eighth sternite slightly emarginate and provided with groups of long conspicuous setæ on either side.

LUZON, Laguna Province, above Ube, altitude 1,625 feet, September 1, 1929 (McGregor); holotype, male; allotype, female, in copula. "Resting flat on upper surface of leaf of *Elatostema* (Urticacæ)." —McGregor; 1 female, August, 1929 (Rivera); paratopotype.

SCAMBONEURA PLUMBEA Alexander.

Scamboneura plumbea ALEXANDER, Philip. Journ. Sci. 21 (1922) 379-380.

The type, a female, was from Pauai, received through Prof. C. F. Baker. A male and two additional females were taken at the type locality, altitude 8,000 feet, April 24-26, 1930, by Rivera. The male is herewith described as allotype.

Male.—Length, about 12.5 millimeters; wing, 12.5; antenna, about 4.2.

Antennæ black throughout, unusually short for this sex. Scutellum gray, concolorous with the remainder of mesonotum; præscutum with indications of four darker gray stripes. Abdominal tergites conspicuously dimidiate, the basal third orange yellow, the broad distal ring black to blue-black; sternites more uniformly yellow, the bases brighter and lighter yellow than the apices. Male hypopygium with the tergite (fig. 35) transverse, the base blackened and with abundant delicate setæ; apical lobes yellow, margined with coarse spinous setæ; a median liguliform pale yellow lobe beneath. Outer dististyle (fig. 36) very broad at base, narrowed to a slender obtuse point. Inner dististyle (fig. 37) shaped as in figure, the blackened apical beak slender; a small group of setigerous tubercles on the outer margin near base. Appendage of ninth sternite (fig. 38) conspicuously bilobed, the entire structure densely set with small stellate groups of setulæ, with longer and more conspicuous setæ at the apices of the lobes.

SCAMBONEURA UNICOLOR Bezzi.

Scamboneura dotata unicolor BEZZI, Philip. Journ. Sci. 12 § D (1917) 112.

Specimens from Ube, Laguna Province, Luzon, March 28 to May 31, 1929 (*Duyag*; *McGregor*); December, 1929 (*Rivera*).

The details of the male hypopygium have never been described and may here be briefly characterized.

Ninth tergite (fig. 39) not heavily chitinized; lateral lobes margined with very delicate setulæ; spines on mesal face of lobes small and weak, merging gradually into marginal setulæ; median lobule compressed. Outer dististyle (fig. 40) pale, flattened, narrowed to a blunt apical point, the outer margin conspicuously dilated. Inner dististyle (fig. 41) a pale blade with numerous retrorse setæ, the apex narrowed to a blunt blackened point. Appendage of ninth sternite (fig. 42) a depressed bilobed structure, the lobes densely set with setulæ.

DOLICHOPEZA (NESOPEZA) HAIGHTENSIS sp. nov.

General coloration testaceous; tibiæ and tarsi white, the tips of the former narrowly darkened; male hypopygium with the tergite small, the margin gently concave, the median portion slightly produced into a minute obtuse lobule.

Male.—Length, about 8 millimeters; wing, 9.5.

Antennæ (male) elongate, if bent backward extending about to one-third the length of the abdomen; flagellar segments elongate-cylindrical, with a dense white pubescence and a few scattered slightly longer black verticils; antennæ pale brownish yellow. Head obscure orange (probably teneral).

Mesonotum testaceous, the præscutum with three reddish stripes. Anterior mesopleura nearly white, the dorsopleural region infuscated. Halteres elongate, pale, the knobs darkened. Legs with the coxæ and trochanters pale; femora dirty white, the tips darkened; tibiæ whitish, the tips narrowly darkened; tarsi white. Wings subhyaline, the stigma darker; veins pale brown; veins beyond the cord with abundant macrotrichia. Venation: Forks of medial field moderately deep, the second and third sections of M_{1+2} subequal, each about two-thirds the length of cell M_1 .

Abdomen with the basal segments pale, the outer segments more darkened, especially the tergites. Male hypopygium (fig. 43) small and of simple construction. Ninth tergite small, the caudal margin gently concave, the median portion produced into a minute obtuse lobule; lateral lobes low, the lateral margins thickened beneath, blackened, and here provided with a few blackened spicules. Outer dististyle, *od*, small, slightly flattened.

LUZON, Mountain Province, Benguet, Pauai, altitude 8,000 feet, April 18, 1930 (*Rivera*); holotype, a teneral male.

Dolichopeza (*Nesopeza*) *haightensis* is very different from the other species described from Luzon and Formosa.

Genus MACGREGOROMYIA Alexander

Macgregoromyia ALEXANDER, Philip. Journ. Sci. 40 (1929) 251.

The accession of more material of the genotype, *M. benguetensis* Alexander, together with the discovery of a second species, *M. brevisector*, necessitates the recasting of the generic characters.

Antennæ 12-segmented, the terminal segment elongate, the apical third narrowed into a false thirteenth segment; flagellar segments cylindrical, with unilaterally arranged, inconspicuous

verticils. Maxillary palpi with the terminal segment long and slender (*benguetensis*) or shorter (*brevisector*). Male hypopygium of simple structure, the tergite not heavily chitinized, the caudal margin with a U-shaped median notch, the lobes obtusely rounded.

The two known species may be separated as follows:

1. Rs with the basal section long and arcuated, exceeding three times the second section; tibiæ uniformly darkened or with the tips insensibly or very narrowly pale..... *M. benguetensis* Alexander.
- Rs with the basal section short, transverse or nearly so, subequal in length to the second section; tibiæ dark, the tips broadly pale yellow.
M. brevisector sp. nov.

MACGREGOROMYIA BENGUETENSIS Alexander.

Macgregoromyia benguetensis ALEXANDER, Philip. Journ. Sci. 40 (1929) 251-252, pl. 1, fig. 3.

A few additional specimens, representing both sexes, from the type locality, Pauai, Mountain Province, Luzon, altitude 8,000 feet, collected April 13 to 20, 1930, by Rivera.

This series of specimens shows a curious variation in venation of the medial field. A certain number of the specimens show m-cu connecting at the fork of M_{3+4} , as originally figured for the species. One specimen shows M_3 fused for a short distance at base with M_{1+2} , as in the genus *Nephrotoma*, m-cu in this instance connecting with M_4 a short distance beyond its origin. In some specimens, the free tip of Sc_2 and R_{1+2} are approximated or actually fused at the wing margin, closing or narrowing cell Sc_2 . The knobs of the halteres are only slightly darkened in almost all specimens.

MACGREGOROMYIA BREVESECTOR sp. nov.

General coloration yellow, the præscutum with three brown stripes; antennal scape yellow, the flagellum black; legs chiefly dark brown, the tips of the tibiæ broadly yellow; wings whitish, the cells beyond the cord chiefly infumed, variegated with areas of the ground color; basal section of Rs short and nearly transverse; tip of R_{1+2} atrophied; m-cu at near one-third the length of M_{3+4} ; cell 2d A narrow.

Male.—Length, about 10.5 millimeters; wing, 11.3.

Frontal prolongation of head obscure yellow above, darker beneath; nasus elongate; palpi with the basal three segments brownish black, the terminal segment yellow, shorter than the combined second and third segments. Antennæ with the scape yellow, the flagellum black. Head brown, very narrowly paler

on the orbits; antennal fossæ with a curved blackened line behind.

Mesonotal præscutum yellow, the interspaces more obscured, the disk with three dark brown stripes, the central portion of the median stripe somewhat paler; scutal lobes darkened, the median region yellow; scutellum and postnotal mediotergite testaceous brown. Pleura yellow, variegated with brown on the sternopleurite, anepisternum, and meron. Halteres very long, yellow, the knobs dark brown. Legs with the coxæ obscure yellow, the outer face of the hind coxæ darkened; trochanters yellow; femora dark brown, paler basally; tibiæ brownish black, the extreme base pale, the tips broadly and conspicuously light yellow, this including about the distal fifth or sixth of the segment; tarsi brownish black; tibial spurs very small. Wings (fig. 5) petiolate at base; ground color of basal cells whitish, those beyond the cord suffused with brown, with whitish areas in their proximal portions, including a prestigmal and a poststigmal area; bases of cells R_s , R_{5+6} , M_1 , 2d M_2 , M_3 , and M_4 , with smaller pale areas; entire central portion of cell 1st M_2 pale; cells C and Sc light brown; stigma and a conspicuous circular cloud on the anterior cord darker brown; veins Cu, 2d A, and m-cu narrowly seamed with brown; outer margin of cell 1st A dusky; veins black, those in the costal region paler. Venation: As in *benguetensis*, with the following exceptions: Basal section of R_s short and nearly transverse, weakly angulated at midlength, about equal in total length to the second section of R_s ; tip of R_{1+2} atrophied; cell 1st M_2 roughly elongate-oval in outline; basal section of M_{2+4} a trifle shorter than the second section; basal section of M_3 subequal to or shorter than m-cu; m short; cell 2d A very narrow.

Abdominal tergites black, the segments narrowly ringed with obscure yellow, before the narrowly darkened apices; sternites more uniformly obscure yellow; subterminal segments and hypopygium more uniformly darkened. Male hypopygium with the ninth tergite (fig. 44) pale, the caudal margin with a deep conspicuous U-shaped notch, the lateral lobes obtusely rounded, provided with an additional very small lateral lobule. Dististyles as illustrated (figs. 45 and 46).

LUZON, Mountain Province, Benguet, Pauai, altitude 8,000 feet, April 18, 1930 (*Rivera*); holotype, male; allotype, female, April 26, 1930; paratypes, 4 males, April 21 to 26, 1930; Bontoc Subprovince, Mount Data, April 29, 1930, resting on a leaf (*Rivera*), paratype, male.

Macgregoromyia brevisector is very distinct from the genotype, *M. benguetensis* Alexander; both species are known only from the highest mountains of northern Luzon.

LIMONIINÆ

LIMONIINI

LIMONIA (LIMONIA) LIGAYAI sp. nov.

General coloration reddish testaceous, the mesonotum variegated with brown; antennæ black; thoracic pleura with a longitudinal black stripe; legs and halteres darkened; wings tinged with blackish; Sc long, Sc_2 at the tip of Sc_1 ; male hypopygium with the ventral dististyle small, the rostral prolongation very long and slender; dorsal dististyle setiferous on basal three-quarters; gonapophyses appearing as blackened, weakly sinuous horns.

Male.—Length, about 4.2 to 4.4 millimeters; wing, 5.5 to 5.6.

Female.—Length, about 5 millimeters; wing, 5.3 to 5.5.

Rostrum and palpi black. Antennæ black throughout; flagellar segments short-cylindrical, with very short apical pedicels; segments covered with a short white pubescence and with relatively short unilaterally arranged verticils; terminal segment longer than the penultimate, pointed at apex. Head brownish gray.

Mesonotum light reddish testaceous, the præscutum with three ill-delimited brown stripes, the scutal lobes extensively darkened. Pleura clear yellow ventrally, the dorsal portions chiefly occupied by a narrow longitudinal black stripe; dorsopleural region darkened. Halteres brownish black, the base of the stem narrowly yellow. Legs with the coxæ and trochanters light yellow; femora light yellow basally, the tips broadly brownish black, broadest on the forelegs where it includes more than the outer three-fourths, narrowest on the posterior legs where approximately the outer fifth is darkened; tibiæ pale brown, the tips a little darkened; tarsi brown, the posterior tarsi a trifle paler. Wings (fig. 6) with a strong blackish tinge, the small oval stigma darker brown; veins brownish black. Costal fringe of both sexes relatively long and conspicuous. Venation: Sc long, Sc_1 ending beyond midlength of Rs , Sc_2 at its tip; Rs arcuated to weakly angulated and short-spurred at origin; free tip of Sc_2 nearly its own length before R_2 ; cell 1st M_2 closed; m-cu close to fork of M ; vein 2d A long.

Entire abdomen dark brown. Male hypopygium (fig. 47) with the tergite, 9 t , unusually long, narrowed outwardly, the

caudal end very gently emarginate. Basistyle, *b*, with the ventromesal lobe basal in position, stout. Ventral dististyle, *vd*, small, appearing as an oval fleshy lobe provided with long coarse setæ; rostral prolongation very long and slender, gently curved; spines pale, two in number, basal in position. Dorsal dististyle long and slender, the long acute apex decurved; basal three-fourths of style with abundant appressed setæ. Gonapophyses, *g*, appearing as blackened, weakly sinuous horns, the tips subacute. Ædeagus, *a*, stout, bifid at tip.

LUZON, Mountain Province, Benguet, Pauai, altitude, 8,000 feet, April 15 to 26, 1930 (*Rivera*); holotype, male; allotype, female; paratypes, 7 males and females; Laguna Province, above Ube, altitude 1,500 feet, February 3 to 9, 1930 (*Rivera*); paratypes, 2 males.

Limonia (*Limonia*) *ligayai* is named in honor of Mr. Macario Ligaya, artist of the Philippine Bureau of Science, to whom I express my indebtedness for his coöperation in preparing the plates of figures accompanying this series of papers. The species is clearly defined by the combination of characters diagnosed above.

LIMONIA (LIBNOTES) NEOFAMILIARIS sp. nov.

General coloration ochereous, the mesonotal præscutum darkened in front; head black; wings whitish subhyaline, cells C and Sc more yellowish brown; stigma dark brown; abdominal tergites dark brown, the sternites and hypopygium yellow.

Male.—Length, about 8 millimeters; wing, 10.4.

Rostrum and palpi black. Antennæ black throughout; flagellar segments becoming more slender and elongate outwardly; longest verticils unilaterally arranged and much exceeding the segments; terminal segment longer than the penultimate. Head black, sparsely pruinose; anterior vertex reduced to a narrow strip.

Pronotum darkened medially, paling to yellow on sides. Mesonotum ochereous, the præscutum vaguely darker medially, especially on anterior half. Pleura ochereous, vaguely marked with more reddish ochereous on the sternopleurite. Halteres dirty white, the knobs darkened. Legs with the coxæ and trochanters yellow; remainder of legs light brown. Wings (fig. 7) whitish subhyaline, cells C and Sc more yellowish brown; stigma relatively small, trigonal, dark brown; veins black, the prearcular and costal veins paler. Venation: Sc₁ ending beyond r-m, Sc₂ some distance from its tip; Rs long, gently sinuous, in alignment with the basal section of R₄₊₅ and approximately four times

as long; free tip of Sc_2 and R_2 in transverse alignment; cell 1st M_2 small, m-cu at midlength; anal veins divergent.

Abdominal tergites dark brown, the sternites yellow; hypopygium pale. Male hypopygium (fig. 48) with the tergite, 9t, transverse, the caudal margin with a low V-shaped emargination, the lateral lobes with long conspicuous setæ. Basistyle, *b*, much smaller than the ventral dististyle, *vd*; rostral prolongation of latter stout, slightly blackened, the two spines unequal in diameter, the outermost a little shorter and stouter. Dorsal dististyle a powerful sickle. Gonapophyses, *g*, with the outer margin toothed.

LUZON, Mountain Province, Benguet, Mount Santo Tomas, above Baguio, altitude over 5,000 feet, October 9, 1929 (*Duyag*); holotype, male.

According to Edwards, *Limonia* (*Libnotes*) *familiaris* (Osten Sacken) has the male hypopygium with elongate basistyles and small ventral dististyles, thus differing from the two species described herein as *subfamiliaris* sp. nov. and *neofamiliaris* sp. nov., both of which have short basistyles and a large fleshy ventral dististyle. The present species differs from *subfamiliaris* by the size, coloration, and details of venation.

LIMONIA (LIBNOTES) SUBFAMILIARIS sp. nov.

General coloration fulvous yellow, the thorax unmarked; head blackish gray; wings yellowish subhyaline, the base and costal region more yellowish; stigma small, dark brown; R_2 and free tip of Sc_2 in transverse alignment; male hypopygium with the spines of the rostral prolongation of the ventral dististyle very unequal, the innermost reduced to a slender seta.

Male.—Length, about 6.5 millimeters; wing, 9.

Rostrum dark brown; palpi black. Antennæ brownish yellow, the incisures clearer yellow; verticils of segments very long, arranged chiefly unilaterally; terminal segment elongate. Head blackish gray, the orbits narrowly light gray; anterior vertex very narrow.

Thorax light fulvous yellow, entirely unmarked. Halteres pale. Legs with the coxæ and trochanters fulvous yellow; femora brownish yellow, gradually darkened outwardly, the extreme tips vaguely paler; tibiæ and tarsi dark brown. Wings (fig. 8) yellowish subhyaline, the prearcular and costal regions more yellowish; stigma small, dark brown, subcircular; veins dark brown, paler in the flavous areas. Venation: Sc long; Rs nearly straight, in alignment with the basal section of R_{4+5}

and approximately twice as long; free tip of Sc_2 and R_2 in transverse alignment; cell 1st M_2 relatively small; m-cu at from near one-third to two-fifths the length of the cell.

Abdomen fulvous, the hypopygium pale. Male hypopygium with the tergite transverse, its caudal margin with a shallow V-shaped emargination, the lobes densely set with conspicuous setae, the outer ones larger and coarser. Rostral prolongation of ventral dististyle stout, the two spines very unequal in size, the outer stout, the inner nearly as long but reduced to a mere seta. Gonapophyses with the outer margin before apex microscopically toothed.

LUZON, Pampanga Province, Mount Arayat, October, 1929 (*Rivera*); holotype, male.

LIMONIA (LIBNOTES) PERPARVULA sp. nov.

Size very small (wing, male, less than 4.5 millimeters); general coloration yellow, the præscutum variegated with brown; knobs of halteres blackened; legs brown, the tips of the femora narrowly yellow; wings grayish, the stigma a little darker than the ground color; male hypopygium with the ventral dististyle entirely without rostral spines.

Male.—Length, about 3.5 millimeters; wing, 4.3.

Rostrum and palpi black. Antennae black throughout; flagellar segments with stout glabrous apical necks that are concolorous with the remainder of the segment; segments with long, unilaterally arranged verticils. Head dark, the anterior vertex and orbits gray; anterior vertex very narrow.

Mesonotal præscutum yellow, with a median dark brown stripe; lateral margins of the sclerite behind the pseudosutural foveae slightly darkened; posterior sclerites of mesonotum more testaceous yellow. Pleura yellow. Halteres yellow, the knobs blackened. Legs with the coxae and trochanters yellow; femora dark brown, the tips narrowly and abruptly yellow; tibiae and tarsi light brown, the terminal segments of the latter darkened; claws long and slender, each with a long basal spine. Wings (fig. 9) grayish, prearcular region and cells C and Sc yellow; stigma oval, very slightly darker than the ground color; veins brown, C, Sc, and R more yellowish. Venation: Sc_1 ending about opposite midlength of the basal section of R_{4+5} ; Sc_2 at its tip; Rs relatively short and straight; distal end of R_1 curving strongly toward R_{2+3} but the free tip of Sc_2 in approximate alignment with R_2 ; m-cu at or just beyond midlength of cell 1st M_2 ; vein 2d A converging slightly towards 1st A at origin.

Abdominal segments dark brown, the caudal margins narrowly yellow; hypopygium chiefly pale. Male hypopygium (fig. 49) with the caudal margin of the tergite, 9*t*, transverse. Basistyle, *b*, long, the ventromesal lobe very low and obtuse. Dorsal dististyle a nearly straight rod. Ventral dististyle fleshy, the oval body set with long coarse setæ, the stout rostral prolongation without evident spines; on face of style near base of prolongation with a corrugated plate. Gonapophyses, *g*, with the mesal apical lobes very long and slender.

LUZON, Pampanga Province, Mount Arayat, October, 1929 (*Rivera*); holotype, male.

Limonia (*Libnotes*) *perparvula* is very distinct from all regional species of the subgenus.

LIMONIA (LIBNOTES) ELATA sp. nov.

General coloration fulvous; hypopygium black; femora yellow, tipped with black; wings relatively narrow; veins beyond cell 1st M_2 elongate; cell 2d A narrow; male hypopygium with the dorsal dististyle a yellow cultriform blade.

Male.—Length, about 11 millimeters; wing, 14.5.

Rostrum and palpi black, the former of moderate length only. Antennæ brown; flagellar segments oval, more slender and attenuate outwardly, each with a seta of unusual length, unilaterally arranged. Head reddish brown, the front and anterior vertex more infuscated; anterior vertex (male) reduced to a linear strip.

Thorax opaque fulvous, without evident markings. Halteres fulvous, the knobs brownish black. Legs with the coxæ and trochanters fulvous; femora yellow, the tips conspicuously blackened; tibiæ and basitarsi yellow, narrowly darkened at tips; remainder of tarsi dark brown. Wings (fig. 10) much narrower than in *termitina*, all cells correspondingly narrowed and more elongate; membrane with a conspicuous brown suffusion, quite as in *termitina*; stigma (male) large, elongate, brown, the costal margin being paler than the stigma; extreme wing tip dark brown; veins dark brown. Venation: R_2 joining R_1 at a more abrupt angle than in *termitina*; outer radial veins deflected strongly caudad at tips; cell 1st M_2 long and narrow, the veins beyond it unusually elongate, the cell being about one-half of vein M_3 beyond it; m-cu just before midlength of the cell; cell 2d A narrow, at near midlength very closely approaching vein 1st A.

Abdomen fulvous, the hypopygium blackened. Male hypopygium (fig. 50) with the caudal margin of the tergite, 9t, nearly straight or very slightly emarginate. Basistyles, *b*, large, especially the ventromesal lobe. Ventral dististyle, *vd*, small, oval, with very long coarse setæ; rostral prolongation elongate, yellow, at base with two approximated spines of nearly equal length, a little exceeding one-half the length of the prolongation; on face of style near base of prolongation with a tubercle that bears two very long slender spinous setæ. Dorsal dististyle, *dd*, stout, yellow, the apex subcultriform.

LUZON, Pampanga Province, Mount Arayat, altitude 3,100 feet, October, 1929 (*Rivera*); holotype, male.

Limonia (*Libnotes*) *elata* is most similar to *L. (L.) termitina* (Osten Sacken), differing in the narrow wings and details of venation.

LIMONIA (DISCOBOLA), probably ARGUS (Say).

Limnobia argus SAY, Long's Exped., Append. (1824) 358.

A female specimen, taken at Pauai, Mountain Province, altitude 8,000 feet, April 11, 1930, by *Rivera*, probably belongs to this widely distributed crane fly.

LIMONIA (DICRANOMYIA) BENGUETENSIS sp. nov.

Belongs to the *morio* group; abdominal segments black, their caudal margins yellow; male hypopygium with the caudal margin of tergite bearing two slender lobes; basistyle with the ventromesal lobe stout, dark-colored; outer dististyle bifid at apex; rostral spine of ventral dististyle apparently lacking.

Male.—Length, about 4.8 millimeters; wing, 5.8.

Rostrum, palpi, and antennæ black; flagellar segments oval, becoming more slender and elongate outwardly. Head black, the anterior vertex silvery.

Mesonotum polished black, the median region of the scutum more pollinose. Pleura black, chiefly covered with a conspicuous silvery pruinosity, the ventral sternopleurite and ventral anepisternum polished black. Halteres yellow, the knobs brownish black. Legs with the fore coxæ darkened, the other coxæ and all trochanters obscure yellow; femora obscure yellow, passing into brownish black at tips; tibiæ and tarsi black. Wings (fig. 11) with a strong brown tinge, the oval stigma darker brown; veins dark brown. Venation: *Sc*₁ very long, ending just before the origin of *Rs*; *m-cu* at fork of *M*; cell 2d *A* wide.

Abdomen black, the segments broadly ringed caudally with yellow; terminal segments, including the hypopygium, more uni-

formly blackened. Male hypopygium (fig. 51) with the tergite, 9t, transverse, the caudal margin produced into two slender lobes that are separated by a rounded notch. Ventromesal lobe of basistyle, *b*, relatively stout, darkened, provided with three powerful fasciculate setæ, two at apex; basistyle without other armature of tubercles and setiferous groups, as in *nesomorio*. Dorsal dististyle slender, expanded and bifid at apex. Ventral dististyle, *vd*, oval, with long coarse setæ, gradually narrowed to the elongate rostral prolongation; rostral spine lacking or reduced to a tiny tubercle (possibly longer and broken in the unique type). Gonapophyses, *g*, darkened, the mesal apical lobe short. Ædeagus broad, the lateral margins fringed with delicate curved setæ.

LUZON, Mountain Province, Benguet, Mount Santo Tomas, above Baguio, over 5,000 feet, October 9, 1929 (*Duyag*); holotype, male.

Limonia (*Dicranomyia*) *benguetensis* is quite distinct from the Formosan *L. (D.) nesomorio* (Alexander), which seems to be its closest relative.

LIMONIA (GERANOMYIA) BIFIDARIA sp. nov.

General coloration yellow, variegated with brown; body stout; rostrum black, relatively short; femora and tibiæ dark brown; wings grayish yellow, with a sparse brown pattern; Sc long; cell 1st M_2 closed; male hypopygium with the ventral dististyle large and fleshy, the rostral prolongation small, with two closely approximated spines; gonapophyses with the mesal apical lobe conspicuously bidentate.

Male.—Length, excluding rostrum, about 7 millimeters; wing, 8; rostrum, about 2.7.

Rostrum relatively short and stout, black, including the palpi. Antennæ short, black throughout, the flagellar segments oval, with inconspicuous verticils. Head blackish, the anterior vertex with a narrow silvery median line.

Pronotum brown medially above, more yellowish laterally. Mesonotal præscutum yellow, brightest laterally, with three brown stripes, the median stripe becoming obsolete before the suture, the laterals crossing the suture onto the scutal lobes; median region of scutum and the scutellum more yellowish; postnotal mediotergite more plumbeous, paler medially in front and more narrowly so on lateral margins. Pleura greenish testaceous, the anepisternum and dorsopleural membrane extensively infuscated. Halteres pale, strongly tinged with

green. Legs with the coxæ and trochanters greenish yellow; femora dark brown, the bases yellowish; tibiæ black; tarsi paling to yellowish brown, the outer segments darker. Wings (fig. 12) relatively narrow, with a strong grayish yellow ground color, very sparsely patterned with darker, including three small subcostal areas before the larger stigma; very narrow and indistinct seams along cord and outer end of cell 1st M_2 , and at end of vein R_3 ; veins pale, darker in the clouded areas. Venation: Sc long, Sc_1 ending at near two-thirds the length of Rs , Sc_2 close to its tip; a supernumerary crossvein in cell Sc ; cell 1st M_2 long and relatively narrow; m-cu at fork of M .

Abdomen brownish yellow, the tergites darker. Male hypopygium (fig. 52) with the tergite transverse, the lobes low and obtuse, with conspicuous marginal setæ. Basistyle, b , small, the ventromesal lobe large. Ventral dististyle, vd , very large and fleshy, the rostral prolongation small, the two spines arising very close together from small basal tubercles; spines slightly unequal, the inner a trifle longer, gently curved. Dorsal dististyle strongly curved, the narrowed acute tip slightly upcurved. Gonapophyses, g , appearing as conspicuous flattened plates, the mesal apical lobe conspicuously bidentate.

LUZON, Mountain Province, Benguet, Pauai, altitude 8,000 feet, April 18, 1930 (*Rivera*); holotype, male; paratypes, 3 males and females, April 21 to 26, 1930 (*Rivera*).

Limonia (*Geranomyia*) *bifidaria* is readily told by the structure of the male hypopygium, especially the gonapophyses.

LIMONIA (GERANOMYIA) PLEUROPALLORIS sp. nov.

General coloration of mesonotum polished black, the lateral margins of the præscutum yellow; an opaque blackish pruinose area before the suture; pleura yellow, only sparsely pruinose; male hypopygium with the gonapophyses broad, the setæ restricted to the outer half, very delicate.

Male.—Length, excluding rostrum, about 5.5 to 5.8 millimeters; wing, 5.5 to 6; rostrum, 2.8 to 3.

Female.—Length, excluding rostrum, about 6 to 7 millimeters; wing, 6.2 to 7; rostrum, 2.9 to 3.

Rostrum black. Antennæ black. Anterior vertex silvery, the remainder of head dorsally gray.

Mesonotal præscutum with the disk polished black, with an opaque blackish pruinose area on the lateral margin, the remainder of the lateral portions, including the humeral and a presutural area, yellow; scutal lobes black; median region of scutum

and the scutellum chiefly yellow, the latter margined with dusky; postnotal mediotergite black, pruinose, the pleurotergite with a conspicuous blackish area. Pleura pale yellow, with a sparse whitish bloom, the anepisternum and sternopleurite deeper yellow. Halteres greenish yellow. Legs with the coxæ and trochanters yellow; remainder of legs brownish yellow, the terminal tarsal segments blackened. Wings (fig. 13) grayish, the small stigma slightly darker, ill-defined; veins brown. Venation: A supernumerary crossvein in cell Sc at near two-thirds the length; cell 1st M_2 closed; m-cu about one-half its length beyond the fork of M.

Abdominal tergites obscure brownish yellow, clearer yellow laterally; sternites clear yellow, the incisures narrowly dark brown; hypopygium yellow. Male hypopygium with the gonapophyses much broader than in either *argentifera* or *nigronotata*, the setulæ very delicate and restricted to the outer half or less.

LUZON, Laguna Province, Calamba, April 6, 1930 (*McGregor*); holotype, male; allotype, female; paratypes, 4 males and females. "Resting on upper surface of leaf of a small *Ficus* shrub, which overhung a small stream."—McGregor.

Limonia (*Geranomyia*) *pleuropalloris* is related to *L. (G.) argentifera* (de Meijere) and *L. (G.) nigronotata* (Brunetti), differing most evidently in the præscutal pattern, the clearer yellow mesopleura, and the details of structure of the male hypopygium, as the broader gonapophyses with the setulæ very small and delicate, restricted to the distal half.

LIMONIA (DOANEOMYIA) PAMPANGENSIS sp. nov.

General coloration light brown; legs black, the tibiæ with the base and apex broadly and subequally white; tarsi snowy white; wings with a dusky tinge; stigma small; Sc long, ending shortly before the origin of Rs.

Male.—Length, about 5 millimeters; wing, 5.4 to 5.5.

Female.—Length, about 5.3 millimeters; wing, 5.5.

Rostrum reddish brown; palpi black. Antennæ relatively elongate, black; flagellar segments oval, with long apical pedicels. Head light brown, the center of the vertex darker.

Mesonotum light brown, subnitidous, without distinct markings, except that in cases the præscutum is more darkened medially. Pleura more testaceous yellow, the ventral sternopleurite a little darker. Halteres elongate, dark brown. Legs with the coxæ and trochanters ocherous; femora black; tibiæ black, the base and apex rather broadly white, the amount subequal

at either end; tarsi white, the outer segments more yellowish. Wings (fig. 14) with a dusky tinge; stigma very small, sub-circular; veins dark brown. Venation: Sc long, Sc₁ ending shortly before origin of Rs, Sc₂ far from the tip of Sc₁, the latter subequal to or longer than Rs; cell 2d M₂ deep; m-cu at or beyond the fork of M, nearly transverse or oblique, longer to much longer than the distal section of Cu₁; cell 1st A relatively long and narrow; no vestige of either Cu₂ or 2d A.

Abdomen dark brown, including the hypopygium. Male hypopygium with the rostral spines much longer and more conspicuous than in *tahitiensis* (Alexander).

LUZON, Pampanga Province, Mount Arayat, October, 1929 (Rivera); holotype, male; allotype, female; paratypes, 2 males.

The discovery of members of the otherwise strictly Australasian group *Doaneomyia* in the Philippine Islands is a matter of great interest. *Limonia* (*Doaneomyia*) *pampangensis* is closest to *L. (D.) albitarsis* (Edwards), of New Hebrides, differing especially in the details of venation and coloration.

LIMONIA (DOANEOMYIA) PAMPANGENSIS MAQUILINGIA subsp. nov.

A slightly different race having the white pattern at base of all tibiae in both sexes much narrower, approximately one-half as wide as the white apex.

LUZON, Laguna Province, Mount Maquiling, September 14, 1929 (Rivera); holotype, male; allotype, female; paratype, female.

LIMONIA (THRYPTICOMYIA) OCTOSETOSA sp. nov.

Size small (wing not exceeding 5 millimeters); proximal ends of basitarsi darkened; male hypopygium with the ninth tergite deeply emarginate, each lateral lobe with about four powerful marginal setae; ventromesal lobe of basistyle without a modified apical seta; mesal apical lobe of each gonapophysis relatively slender, darkened.

Male.—Length, about 4.5 to 5 millimeters; wing, 4 to 5.

Female.—Length, about 4 to 4.3 millimeters; wing, 4 to 4.5.

General appearance much as in *apicalis* (Wiedemann). Antennae relatively elongate, in male, if bent backward extending to beyond base of abdomen. Mesonotum light yellowish brown, the median region of præscutum and the scutal lobes darker. Proximal ends of basitarsi darkened, this somewhat narrower on the forelegs. Wings (fig. 15) with the apex only slightly darkened. Venation: Sc₁ ending opposite or shortly before origin of Rs; Sc₂ variable in position, in some cases far from tip,

in others much nearer tip; m-cu beyond midlength of cell 1st M_2 , the inner end of the latter arcuated.

Male hypopygium (fig. 53) differing in all details from allied regional species. Ninth tergite, 9t, deeply notched, the lateral lobes each with about four powerful marginal setæ, the most lateral largest, in cases with an additional median seta. Mesal lobe of basistyle, *b*, relatively stout, without a conspicuous elongate apical seta (as in *microstigma* Alexander and *unisetosa* Alexander). Spines of the rostral prolongation of the ventral dististyle, *vd*, small, the basal enlargements very small to virtually lacking; setæ of apex of rostral prolongation small and relatively insignificant, on the outer margin confined to the extreme end. Gonapophyses, *g*, with the mesal apical lobe long and slender, darkened.

LUZON, Pampanga Province, Mount Arayat, October, 1929 (*Rivera*); holotype, male; allotype, female; paratypes, several of both sexes.

Limonia (*Thrypticomys*) *octosetosa* is most readily told by the structure of the male hypopygium.

HELIUS (EURHAMPHIDIA) DIACANTHUS sp. nov.

General coloration yellow, the mesonotal præscutum with a median brown stripe; femoral tips and tibial bases broadly snowy white, the amount subequal; wings with a faint dusky tinge, cells C and Sc darker; vein 2d A relatively short; outer dististyle and lateral ends of tergite both bispinous.

Male.—Length, about 5 millimeters; wing, 5.5 to 5.7.

Rostrum a little longer than the head, brownish black; palpi black. Antennæ with the scapal segments pale yellow, the flagellum brownish black; antennæ of moderate length, the flagellar segments long-oval, the outer ones becoming more slender and attenuate. Head gray.

Mesonotum yellow, the præscutum with a median dark brown stripe; remainder of notum yellow, the scutal lobes conspicuously darkened; scutellum infuscated, narrowly paler apically; postnotal mediotergite dark brown, narrowly paler laterally. Pleura yellow. Halteres brown, the base of the stem narrowly pale yellow. Legs with the coxæ and trochanters pale yellow; femora brown, paler at base, deepening outwardly, the tips broadly snowy white; tibiæ black, the base broadly white, a trifle narrower than the femoral tip, the apex broadly white, about three times as extensive as the pale base; tarsi snowy white, the terminal two segments darkened. Wings (fig. 16) with a faint dusky tinge, cells C, Sc, and extreme base of Cu more darkened;

stigma oval, dark brown; veins brownish black. Venation: As in *perelegans*, with the following differences: Sc longer, both Sc₁ and Sc₂ ending about opposite one-fourth the length of the distal section of Rs; basal section of Rs longer; vein 2d A shorter.

Abdominal tergites brown, the subterminal segments darker brown; hypopygium brighter. Male hypopygium (fig. 54) with the lateral arms of the tergite, 9t, conspicuously bispinous, the small lateral arm slender and strongly curved. Outer dististyle, od, a curved chitinized rod, bidentate at tip.

LUZON, Mountain Province, Benguet, Pauai, altitude 8,000 feet (*Rivera*); holotype, male, April 24, 1930; paratype, male, April 11, 1930; paratypes, 4 males and females, April 22 to 27, 1930 (*Rivera*).

There are several species of *Eurhamphidia* in the Austro-Oriental fauna which have the genua broadly white. The present species differs from *Helius* (*Eurhamphidia*) *abnormalis* (Brunetti) in the details of structure of the male hypopygium, especially of the lateral arms of the tergite, 9t, and the outer dististyle, od (fig. 55). It seems to be more closely allied to *H. (E.) perelegans* Alexander (Formosa) which is still known only in the female sex, differing most evidently in the coloration of the body, wings, and legs, as the darkened costal region of the wings and the unusual amount of white on the bases of the tibiæ.

HEXATOMINI

ADELPHOMYIA LUZONENSIS sp. nov.

General coloration obscure yellow, the præscutum with dark brown lateral stripes, the median stripe obsolete or nearly so; dorsal thoracic pleurites darkened; legs yellow, the tips of the femora and tibiæ dark brown; wings yellowish gray, with a conspicuous brown pattern, including spots beyond arculus, origin of Rs, along cord and outer end of cell 1st M₂ and on Sc₂; R₂ at fork of R₃₊₄.

Female.—Length, about 5 millimeters; wing, 5.

Rostrum and palpi dark brown. Antennæ with the scapal segments dark brown, the flagellum much paler; flagellar segments short-oval, becoming more elongate outwardly, with conspicuous verticils that exceed the segments in length. Head obscure yellow, the central portion of the vertex extensively blackened.

Pronotum testaceous above, blackened laterally. Mesonotal præscutum obscure yellow, with dark brown lateral stripes, the

median stripe obsolete or nearly so; scutal lobes dark brown; median region of scutum and extreme base of scutellum obscure yellow; remainder of scutellum and postnotal mediotergite brownish black. Pleura with the dorsal portion dark brown, including the fore coxæ, the remaining coxæ and ventral pleurites yellow. Halteres pale yellow, the knobs infuscated. Legs with the trochanters yellow; femora yellow, the tips narrowly but conspicuously blackened; tibiæ yellow, the tips narrowly brownish black; basitarsi yellow, the tips and remainder of tarsi dark brown. Wings (fig. 17) yellowish gray, the prearcular and costal regions light yellow; a conspicuous brown pattern, distributed as follows: Stigma, bases of cells R and M, Sc., along cord and outer end of cell 1st M₂; veins pale, darker in the infuscated areas. Macrotrichia in cells R₃ to M₄, inclusive. Venation: Rs angulated and conspicuously spurred at origin; R₂ at fork of R₃₊₄; cell M₁ present; m-cu at near midlength of cell 1st M₂.

Abdominal tergites dark brown, the sternites obscure yellow, the subterminal sternite darkened. Ovipositor with the tergal valves horn-yellow, upcurved.

LUZON, Mountain Province, Benguet, La Trinidad, below Baguio, altitude 4,800 feet, in open parklike area, March, 1930 (*Rivera*); holotype, female.

Adelphomyia luzonensis is most nearly allied to *A. issikina* Alexander (Formosa), differing especially in the smaller size and details of coloration and venation. The dusky color of the posterior cells of the wing is much less intense than in *issikina* and there is a darkened seam on Sc₂.

EPIPHRAGMA SUBCRENULATA sp. nov.

General coloration brown, the pleura more yellowish beneath; head light ashen gray; halteres brown; legs yellow; wings light brown, the costal region more yellowish, the crossveins and deflections narrowly seamed with brown; axillary region of wing only feebly incised; a series of supernumerary crossveins in cell C but no such element in cell Cu; m-cu more than its own length beyond the fork of M.

Female.—Length, about 8.5 millimeters; wing, 7.3.

Rostrum and palpi black. Antennæ with the scape pale, pruinose, the fusion segment obscure yellow, remainder of flagellum black. Head light ashen gray above, passing into brown on the sides and beneath.

Mesonotal præscutum depressed, light testaceous brown to slightly pruinose, a little paler than the chestnut-brown lateral

portions; scutellum and postnotum slightly pruinose, the latter darkened behind. Pleura infuscated above, the ventral sclerites more yellowish. Halteres elongate, brown. Legs with the coxæ and trochanters yellow; remainder of legs yellow, the femora a very little darker. Wings (fig. 18) light brown, the prearcular and costal regions more yellowish, the coloration continued to beyond the wing tip as large marginal spots at ends of the cells; a restricted brown pattern, appearing as narrow seams at origin of R_s , along cord and outer end of cell 1st M_2 , on the supernumerary crossveins and spurs in cell C, and as marginal clouds at ends of all longitudinal veins, those at R_3 , R_4 , and 2d A most extensive. Axillary region of wing only slightly incised. Venation: A series of about eight supernumerary crossveins and spurs in cell C; cell R_3 relatively deep, the inclosing veins parallel or nearly so; m-cu more than its own length beyond the fork of M; no supernumerary crossvein in cell Cu.

Abdominal segments brownish yellow, narrowly darkened laterally.

LUZON, Mountain Province, Benguet, Mount Santo Tomas, above Baguio, altitude over 5,000 feet, October 9, 1929 (*Duyag*); holotype, female.

Epiphragma subcrenulata requires comparison only with *E. crenulata* Alexander and *E. cinereinota* sp. nov., likewise from the mountains of northern Luzon. From *crenulata* it differs most evidently in the feeble incision of the wing axilla and the details of venation. It differs from *cinereinota* in the body coloration and the nature of the axillary incision.

EPIPHRAGMA CINEREINOTA sp. nov.

General coloration of dorsum of head and thorax light ashen gray, the remainder brown and yellow; antennæ (female) 15-segmented, the fusion segment with only two segments; wings light yellow, with a restricted brown pattern; supernumerary crossveins and spurs in cell C relatively few in number; m-cu at or close to the fork of M; axillary crenulation moderately conspicuous.

Female.—Length, about 10 millimeters; wing, 9.5.

Rostrum and palpi small, black. Antennæ with the scape and fusion segment of flagellum light yellow, the remainder black; antennæ 15-segmented, there being only two segments involved in the basal fusion, the second of these darkened at apex; in *crenulata* there are three segments distinctly involved in the

fusion, all pale in color. Head above light ashy, more infuscated behind and on the sides.

Mesonotum chiefly light ashy, the præscutum in front and on sides abruptly brownish yellow. Pleura yellow, darker behind. Halteres long, brownish yellow, the knobs infuscated. Legs with the coxæ and trochanters pale yellow; remainder of legs obscure yellow, the terminal tarsal segments darkened. Wings (fig. 19) light yellow, the radial field beyond the cord more brownish; a restricted but conspicuous dark brown dotted and spotted pattern, including small marginal spots on all the veins, largest on the anal veins; larger areas at origin of Rs, along cord and outer end of cell 1st M_2 , and at fork of M_{1+2} ; outer ends of radial cells with conspicuous pale yellow areas; veins yellowish, brown in the infuscated areas. Axillary crenulation larger and more conspicuous than in *subcrenulata*, but shallower and more elongate than in *crenulata*. Venation: Supernumerary crossveins and spurs in cell C relatively few, not exceeding seven; Rs longer; cell R_3 deeper; m-cu at or very close to the fork of M.

Abdominal tergites yellowish brown, caudal margins narrowly darker, the outer segments more uniform brown; sternites obscure yellow.

LUZON, Mountain Province, Benguet, Pauai, altitude about 8,000 feet, April 11, 1930 (*Rivera*); holotype, female.

Of the numerous allied species of *Epiphragma* in Luzon, *E. cinereinota* is closest to *E. crenulata* Alexander, differing most conspicuously in the larger size, structure of the antennæ, and the less-developed axillary crenulation of the wing.

LIMNOPHILA (LIMNOPHILA) BENGUETANA sp. nov.

General coloration brown; antennæ short; femora and tibiæ brown; wings cream-colored, heavily patterned with brown, including a series of about six major costal areas; R_2 very faint to subobsolete; m-cu at midlength of cell 1st M_2 ; male hypopygium with the outer dististyle terminating in a simple acute spine.

Male.—Length, about 5 millimeters; wing, 6.2.

Rostrum and palpi black. Antennæ brownish black throughout, short, if bent backward not extending far beyond the pronotum. Head brownish gray.

Mesonotal præscutum with the interspaces sparsely brownish yellow pollinose, the usual three stripes darker brown, the lat-

eral stripes crossing the suture and including the scutal lobes; median region of scutum and the scutellum more yellowish testaceous; postnotum grayish brown. Pleura with the dorsal sclerites darkened, the sternopleurite and meron more yellowish. Halteres yellow. Legs with the coxæ brownish yellow; trochanters obscure yellow; femora and tibiæ light brown, the tips of the latter slightly darkened; tarsi brownish black; legs with relatively conspicuous setæ. Wings (fig. 20) with the ground color cream-colored, heavily but rather restrictedly patterned with brown, the areas arranged much as in species of *Ephelia*, there being a heavier costal pattern of about six areas, the first at arculus, the third and fourth confluent into a U-shaped figure that encircles a pale spot beyond vein Sc; paler brownish gray areas at ends of longitudinal veins and as clouds in cells M, Cu, R₅, and the anal cells; veins pale, a very little darker in the clouded areas. Macrotrichia of veins small, restricted to veins beyond cord, except on R₁. Venation: Sc₂ near tip of Sc; Rs long, arcuated at origin, in alignment with R₂₊₃₊₄; R₂ very faint to subobsolete, its apparent location as figured; veins R₃ and R₄ divergent; cell M₁ present but small; m-cu at mid-length of cell 1st M₂; anterior arculus poorly indicated or lacking.

Abdomen more or less bicolored, especially the sternites, the segments obscure yellow, margined caudally by dark brown; hypopygium chiefly dark-colored. Male hypopygium (fig. 56) with the outer dististyle, *od*, simple, curved to the simple acute tip, the basal portion with conspicuous setæ. Inner dististyle, *id*, with the tip obtusely rounded. Interbasal process blackened, the apex expanded into a head. Gonapophyses, *g*, appearing as simple chitinized blades. Ædeagus, *a*, short.

LUZON, Mountain Province, Benguet, Pauai, altitude about 8,000 feet, April 20, 1930 (*Rivera*); holotype, male.

Limnophila benguetana is most closely allied to *L. guttularis* Edwards (Borneo), differing in the darkened legs and details of wing pattern and venation. The species has a wing pattern that is virtually the same as that of many Holarctic and Oriental species of the subgenus *Ephelia*. The apparent loss of the anterior arculus and the structure of the male hypopygium are characters strongly suggestive of *Pseudolimnophila*, but the venation is quite typical of *Limnophila*. Edwards has considered that his *guttularis* is a member of the typical subgenus

of *Limnophila* (*Poecilostola* Schiner, syn.) despite the very different general appearance of the species from the genotype of *Limnophila* (*pictipennis* Westwood).

LIMNOPHILA (DICRANOPHRAGMA) PARDALOTA sp. nov.

General coloration of mesonotum yellowish brown; knobs of halteres infuscated; legs yellow; wings relatively narrow, cream-colored, with an abundant dotted and spotted pattern, the areas more elongate and generally parallel in cells M and Cu.

Female.—Length, about 7.5 millimeters; wing, 6.5.

Rostrum and palpi black. Antennæ with the scapal segments black, the flagellum reddish brown, the outer segments darker. Head yellowish brown.

Mesonotal præscutum yellowish brown, the median region a little darker; posterior sclerites of mesonotum a little more pruinose. Pleura dark brownish gray. Halteres pale yellow, the apices of the knobs infuscated. Legs with the fore coxæ dark brown, the remaining coxæ and trochanters yellow; remainder of legs yellow, the terminal tarsal segments dark brown. Wings (fig. 21) relatively narrow, cream-colored, with a very abundant dotted and spotted brown pattern, the major groups lying above the origin of Rs and in the stigmal region; the dots are grouped in all the cells, in cells M and Cu becoming more transversely lengthened and regularly spaced to appear as parallel bands at the ends of the medial, cubital, and anal veins, the areas grouping to form more or less distinct circles; veins yellow, a little darker in the infuscated areas. Venation: Supernumerary crossvein in cell R_3 at near two-thirds the length of the cell; cell M_1 small; m-cu at near one-third the length of the small cell 1st M_2 .

Abdominal tergites dark brown, the sternites more reddish brown, the caudal margins of the segments dark brown. Ovipositor with the shields reddish brown, the elongate valves brownish horn color.

LUZON, Mountain Province, Benguet, Mount Santo Tomas, above Baguio, altitude over 5,000 feet, October 9, 1929 (*Duyag*); holotype, female.

Limnophila pardalota is distinct from all of the numerous species of *Dicranophragma* now known from eastern Asia. The narrow wings with an unusually abundant dotting gives to the fly a conspicuous appearance.

ERIOPTERINI

TOXORHINA (TOXORHINA) MONTINA sp. nov.

General coloration brownish gray; head and posterior sclerites of mesonotum light gray; præscutum with three dark brown stripes; pleura pale, darker dorsally; wings grayish; abdominal tergites darkened; hypopygium black, the tergite deeply emarginate medially, forming long glabrous earlike lobes.

Male.—Length, excluding rostrum, about 4.5 to 5 millimeters; wing, 5.5 to 5.6; rostrum, about 5.

Female.—Length, excluding rostrum, about 7 to 7.5 millimeters; wing, 6 to 6.2; rostrum, about 5.5.

Rostrum elongate, black. Antennæ with the scapal segments yellow, especially the second segment; flagellum black. Head light gray.

Mesonotal præscutum reddish brown, with three dark brown stripes that become confluent posteriorly, or nearly so; humeral region more or less yellowish gray pruinose; scutal lobes dark brown; scutellum and postnotum gray. Pleura chiefly pale, the anepisternum darkened. Halteres dark brown, the base of stem narrowly yellow. Legs with the coxæ and trochanters yellow, the fore coxæ more infuscated; remainder of legs black, the bases of femora restrictedly pale. Wings with a grayish tinge, iridescent; veins black, those of basal half sometimes pale. Venation: Sc_1 ending opposite the origin of Rs , Sc_2 some distance from its tip; m-cu close to fork of M .

Abdominal tergites dark reddish brown, the margins blackened; sternites paler, especially of the basal segments; hypopygium black. Male hypopygium much as in *duyagi*, differing especially in the structure of the tergite, the latter with the caudal margin deeply emarginate, the conspicuous earlike lateral lobes entirely glabrous. In *duyagi*, the median region of the tergite is only slightly notched, the entire margin set with dense short setæ.

LUZON, Mountain Province, Benguet, Mount Santo Tomas, above Baguio, altitude over 5,000 feet, October 9, 1929 (*Duyag*); holotype, male; allotype, female; paratypes, 4 males and females.

Toxorhina montina is very like *T. duyagi* Alexander, but the structure of the ninth tergite of the male hypopygium is amply distinct.

TOXORHINA (TOXORHINA) BICEPS sp. nov.

General coloration yellow, the mesonotum variegated with brown; pleura yellow, unmarked; rostrum longer than the body; wings tinged with dusky; cell 1st M_2 open by the atrophy of m; male hypopygium with the outer dististyle bifid at apex.

Male.—Length, excluding rostrum, about 5.5 millimeters; wing, 6; rostrum, about 6.5.

Rostrum black, longer than the body. Antennæ with the basal segment brown; second segment light yellow; flagellum black. Head gray, the center of the vertex darkened; no corniculus.

Mesonotal præscutum yellow, with three brown stripes, the median stripe becoming obsolete at near midlength of the sclerite, on its anterior portion becoming more or less confluent with the lateral stripes; scutal lobes brownish black; scutellum black; postnotal mediotergite gray. Pleura clear light yellow. Halteres dark brown, the stem somewhat paler, its extreme base yellow. Legs with the coxæ pale yellow; trochanters more whitish; remainder of legs black, only the femoral bases very restrictedly brightened. Wings (fig. 22) with a strong dusky tinge, somewhat more intense in cell M adjoining vein Cu; prearcular and costal regions slightly more yellowish; veins black, somewhat paler at the wing base. Macrotrichia on entire length of Rs and on all branches of M and Cu beyond the cord. Venation: Sc₁ ending just beyond origin of Rs; cell 1st M₂ open by the atrophy of m; m-cu a short distance before the fork of M.

Abdominal tergites dark brown, the sternites light yellow; ninth segment light yellow, the basistyles again dark brown. Male hypopygium (fig. 57) with the outer dististyle, *od*, small, at apex with two slender blunt arms that form about a straight angle. Inner dististyle, *id*, longer, arcuate, at near midlength on outer margin with a small pale flange. Arms of ædeagus, *a*, short and stout.

LUZON, Mountain Province, Benguet, Mount Santo Tomas, above Baguio, altitude over 5,000 feet, March 21, 1930 (*Rivera*); holotype, male.

Toxorhina biceps is very different from *T. duyagi* Alexander and *T. montina* sp. nov. in the structure of the male hypopygium, notably of the outer dististyle.

ERIOPTERA (ERIOPTERA) RUBRIPES sp. nov.

General coloration yellowish brown, the præscutum with three brown stripes; head black, the broad orbits light gray; pleura obscure yellow, variegated with darker; knobs of halteres brownish black; legs reddish yellow, only the terminal tarsal segments darkened; wings with a strong grayish yellow suffusion, the costal cell whitish, the prearcular and remainder of costal region yellowish.

Female.—Length, about 5.5 to 6 millimeters; wing, 6 to 6.2.

Rostrum and basal segments of palpi obscure yellow, the terminal segments of the latter blackened. Antennæ brown, of rather unusual length for the female sex; flagellar segments long-oval to subcylindrical. Head black, the front and broad orbits light gray.

Mesonotal præscutum and scutum yellowish brown, the former with the three usual stripes darker, the scutal lobes similarly infumed; pseudosutural foveæ pale; scutellum brown, broadly margined behind with obscure yellow; postnotal mediotergite light brown, the cephalic portion darker with a more or less distinct yellow spot on sides. Pleura obscure yellow, the fore coxæ and a spot on dorsal portion of anepisternum dark brown; hypopleura and pleurotergite variegated paler brown and yellow, with a distinct bluish cast; sternum and meron clear light yellow. Halteres pale, the knobs brownish black. Legs with the coxæ yellow, more or less pruinose and darkened, especially the fore coxæ, as described; trochanters yellow; remainder of legs reddish yellow, the terminal tarsal segments darkened. Wings with a strong grayish yellow suffusion, the prearcular and costal regions clearer yellow; cell C almost white; certain of the veins, as R_5 and Cu_1 narrowly bordered by light yellow; veins pale to yellow, the long macrotrichia brown or black. Venation: R_{2+3+4} a little longer than the basal section of R_5 ; M_4 and Cu_1 deflected strongly cephalad at outer ends; vein 2d A strongly sinuous, as in the subgenus.

Abdominal tergites dark brown, the caudal margins of the outer segments narrowly yellow, on the genital segment including the entire sclerite; sternites dark, the outer segments margined caudally and more restrictedly laterally with yellow. Ovipositor with the slender smooth valves horn-yellow.

LUZON, Mountain Province, Benguet, Mount Santo Tomas, above Baguio, altitude over 5,000 feet, March 21, 1930 (*Rivera*); holotype, female; La Trinidad, below Baguio, in open parklike area, altitude about 4,800 feet, April 20, 1930 (*Rivera*); paratype, female; Laguna Province, near Ube, in boggy area, March 4, 1930 (*McGregor*); paratype, female.

Erioptera (Erioptera) rubripes is amply distinct from similar large regional species in the combination of wing coloration, blackened knobs of halteres, and unvariegated legs.

ILLUSTRATIONS

[Legend: a, ædeagus; b, basistyle; dd, dorsal dististyle; g, gonapophysis; id, inner dististyle; od, outer dististyle; t, tergite; vd, ventral dististyle.]

PLATE 1

- FIG. 1. *Tipulodina pampangensis* sp. nov., wing.
 2. *Scamboneura subtransversa* sp. nov., wing.
 3. *Scamboneura primogenia* sp. nov., wing.
 4. *Scamboneura banahaoensis* sp. nov., wing.
 5. *Macgregoromyia brevisector* sp. nov., wing.
 6. *Limonia (Limonia) ligayai* sp. nov., wing.
 7. *Limonia (Libnotes) neofamiliaris* sp. nov., wing.
 8. *Limonia (Libnotes) subfamiliaris* sp. nov., wing.
 9. *Limonia (Libnotes) perparvula* sp. nov., wing.
 10. *Limonia (Libnotes) elata* sp. nov., wing.
 11. *Limonia (Dicranomyia) benguetensis* sp. nov., wing.
 12. *Limonia (Geranomyia) bifidaria* sp. nov., wing.
 13. *Limonia (Geranomyia) pleuropalloris* sp. nov., wing.
 14. *Limonia (Doaneomyia) pampangensis* sp. nov., wing.
 15. *Limonia (Thrypticomyia) octosetosa* sp. nov., wing.
 16. *Helius (Eurhamphidia) diacanthus* sp. nov., wing.
 17. *Adelphomyia luzonensis* sp. nov., wing.
 18. *Epiphragma subcrenulata* sp. nov., wing.
 19. *Epiphragma cinereinota* sp. nov., wing.
 20. *Limnophila (Limnophila) benguetana* sp. nov., wing.
 21. *Limnophila (Dicranophragma) pardalota* sp. nov., wing.
 22. *Toxorhina (Toxorhina) biceps* sp. nov., wing.

PLATE 2

- FIG. 23. *Scamboneura subtransversa* sp. nov., male hypopygium, ninth tergite.
 24. *Scamboneura subtransversa* sp. nov., male hypopygium, inner dististyle.
 25. *Scamboneura subtransversa* sp. nov., male hypopygium, appendage of ninth sternite.
 26. *Scamboneura subtransversa* sp. nov., male hypopygium, margin of eighth sternite.
 27. *Scamboneura primogenia* sp. nov., male hypopygium, ninth tergite.
 28. *Scamboneura primogenia* sp. nov., male hypopygium, dististyles.
 29. *Scamboneura primogenia* sp. nov., male hypopygium, appendage of ninth sternite.
 30. *Scamboneura primogenia* sp. nov., male hypopygium, gonapophysis.
 31. *Scamboneura banahaoensis* sp. nov., male hypopygium, ninth tergite.

- FIG. 32. *Scamboneura banahaoensis* sp. nov., male hypopygium, outer dististyle.
33. *Scamboneura banahaoensis* sp. nov., male hypopygium, inner dististyle.
34. *Scamboneura banahaoensis* sp. nov., male hypopygium, appendage of ninth sternite.
35. *Scamboneura plumbea* Alexander, male hypopygium, ninth tergite.
36. *Scamboneura plumbea* Alexander, male hypopygium, outer dististyle.
37. *Scamboneura plumbea* Alexander, male hypopygium, inner dististyle.
38. *Scamboneura plumbea* Alexander, male hypopygium, appendage of ninth sternite.
39. *Scamboneura unicolor* Bezzi, male hypopygium, ninth tergite.
40. *Scamboneura unicolor* Bezzi, male hypopygium, outer dististyle.
41. *Scamboneura unicolor* Bezzi, male hypopygium, inner dististyle.
42. *Scamboneura unicolor* Bezzi, male hypopygium, appendage of ninth sternite.

PLATE 3

- FIG. 43. *Dolichopeza* (*Nesopeza*) *hightensis* sp. nov., male hypopygium.
44. *Macgregoromyia brevisector* sp. nov., male hypopygium, ninth tergite.
45. *Macgregoromyia brevisector* sp. nov., male hypopygium, outer dististyle.
46. *Macgregoromyia brevisector* sp. nov., male hypopygium, inner dististyle.
47. *Limonia* (*Limonia*) *ligayai* sp. nov., male hypopygium.
48. *Limonia* (*Libnotes*) *neofamiliaris* sp. nov., male hypopygium.
49. *Limonia* (*Libnotes*) *perparvula* sp. nov., male hypopygium.
50. *Limonia* (*Libnotes*) *elata* sp. nov., male hypopygium.
51. *Limonia* (*Dicranomyia*) *benguetensis* sp. nov., male hypopygium.
52. *Limonia* (*Geranomyia*) *bifidaria* sp. nov., male hypopygium.
53. *Limonia* (*Thrypticomys*) *octosetosa* sp. nov., male hypopygium.
54. *Helius* (*Eurhamphidia*) *diacanthus* sp. nov., male hypopygium.
55. *Helius* (*Eurhamphidia*) *abnormalis* (Brunetti), male hypopygium, apex of outer dististyle and gonapophysis.
56. *Limnophila* (*Limnophila*) *benguetana* sp. nov., male hypopygium.
57. *Toxorhina* (*Toxorhina*) *biceps* sp. nov., male hypopygium.

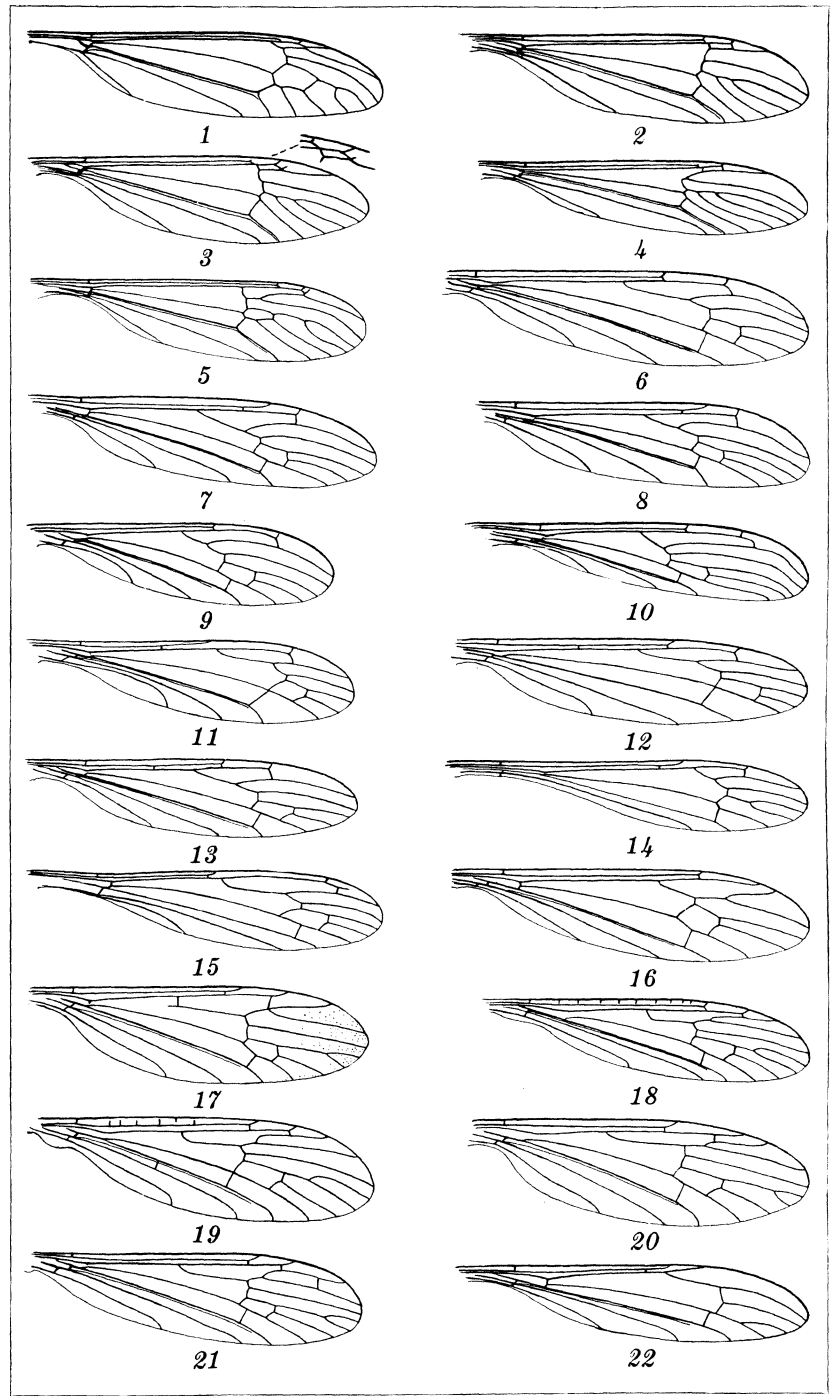


PLATE 1.



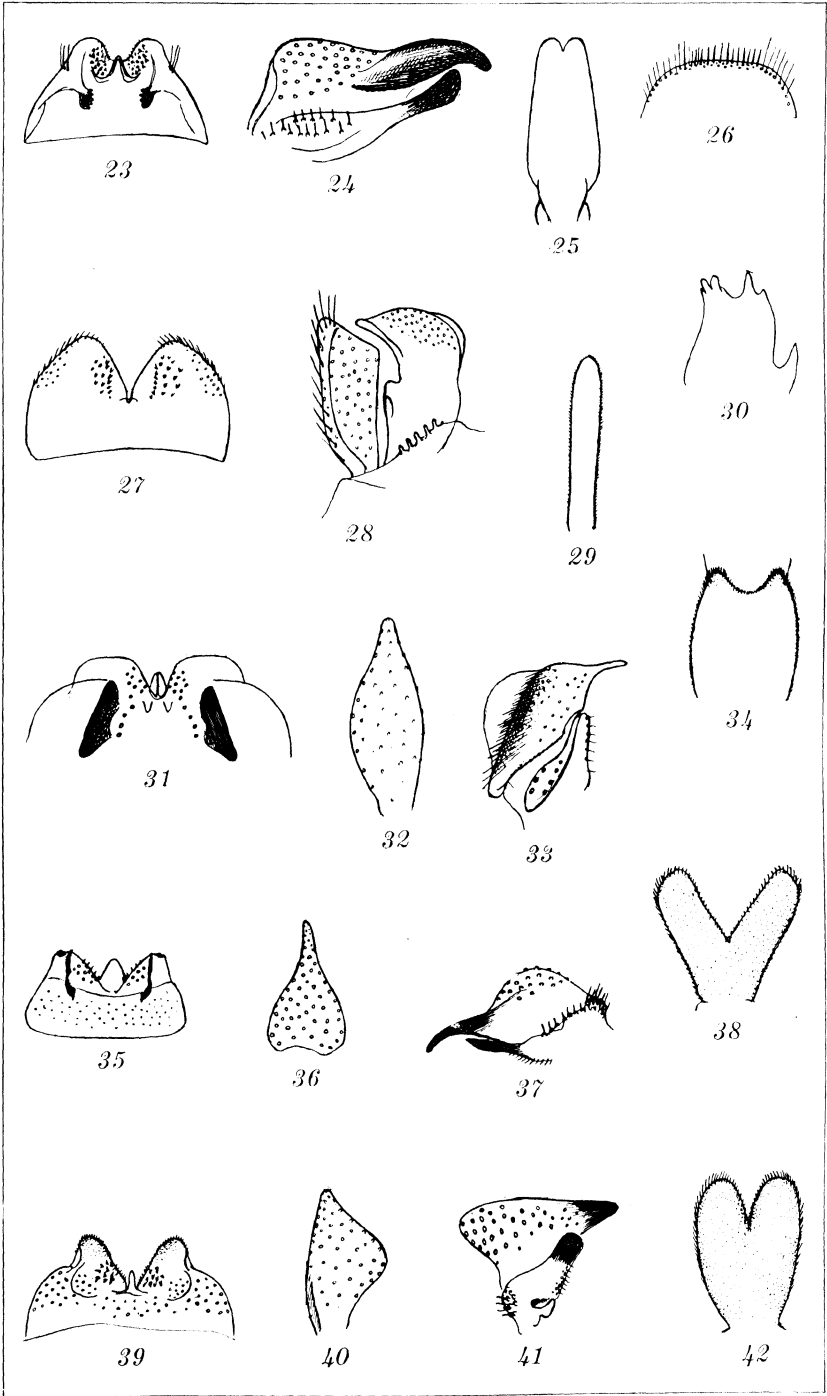


PLATE 2.

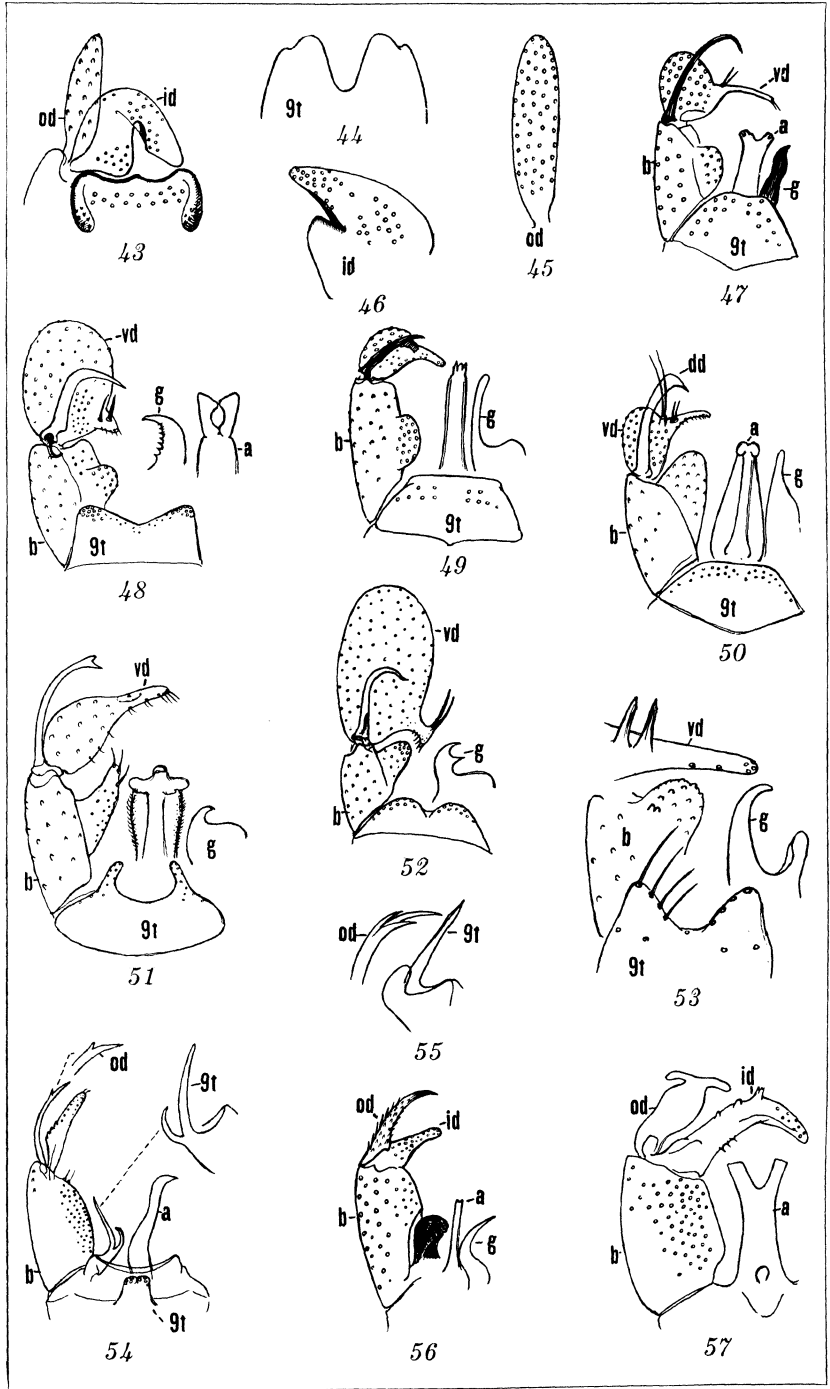


PLATE 3.

STUDIES ON INFANTILE BERIBERI BASED ON FIVE HUNDRED FOURTEEN CASES

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ONE TEXT FIGURE

RETROSPECT

RAVAGES OF THE DISEASE

On account of its ravages, infantile beriberi, or the beriberi affecting infants who are nursed by beriberic mothers, is without doubt the most important infant disease to the Filipino practitioner. Three years ago, the Philippine Committee on Beriberi(1) stated that infantile beriberi claimed an average of 16,500 deaths annually among infants alone, representing 28.10 per cent of the total deaths among infants under 1 year of age. In 1910, I ventured to state that while the mortality among breast-fed infants in the Philippines was 65 per cent, in Germany it was only 9 per cent.(2) The reason for this was the great toll caused by infantile beriberi. In view of this singular fact, unparalleled in the history of medicine, human milk as a food appears to be a scourge to the Filipino infant, an inverse phenomenon to the experience of other nations, where human milk is the strongest bulwark of child hygiene, the "magic liquor" that guarantees the life of the infant.

It should be noted that so long as we consider this disease as adult beriberi in miniature, we shall be committing a gross mistake. Infantile beriberi differs from adult beriberi in almost every particular; pathological, clinical, and therapeutical. The multiple neuritis observed in adults is unknown in infants. The clinical manifestations in them are very peculiar and characteristic. With regard to the effects of specific therapy, tiki-tiki extract has a wonderful effect on infants but is valueless to adults.

HIROTA'S DISCOVERY

Although beriberi as a disease existed from remote antiquity and was known to the Romans as early as 24 B. C., the knowl-

edge was confined to the adult form. Eminent European and Japanese physicians, experts in tropical medicine, were not aware of the existence of infantile beriberi. Baelz claimed to have observed it in children only during the second dentition; that is, at about 6 years of age, and Scheube,⁽³⁾ in his classical book published in 1900, said that the youngest patient he had treated was a child of 8 years. Clark,⁽⁴⁾ of Hongkong, writing in the same year of an epidemic of beriberi in the Berlin Foundling Home of that place, mentioned the occurrence of beriberi among children 4 years old.

The closing years of the 19th century were memorable in the annals of medicine in the Tropics, for then Hirota,⁽⁵⁾ of Tokyo, revealed to the world his transcendental observations on a disease that affected only breast-fed children and hastened the dawn of our knowledge concerning this obscure malady, which he called infantile beriberi. As early as January, 1888, this great Japanese scientist observed in some infants that were brought to his clinic peculiar and strikingly interesting symptoms upon which he based his epoch-making studies. Notable among them were obstinate vomiting, change of humor, incessant crying, constant whining, dyspnoea, oedema, aphonia, diminished amount of urine, accelerated but clear heart beats, slightly coated tongue, negative albumin in the urine, and negative lung findings. He then began to gather cases as they came to his clinic, and after collecting about thirty presented the results of his studies in a meeting of the General Association of the Medical Society of Tokyo, in April, 1891.

His interest did not end there, and from that simple, yet significant beginning, he pursued a more extensive and intensive investigation, and in December, 1897,⁽⁶⁾ reported fifty-two additional cases consisting of thirty-eight males and fourteen females, whose ages varied from 1 to 13 months. Forty-two of these cases were reported as completely cured, five died, and five were of unknown termination.

In the course of this study he noticed two further interesting peculiarities of the disease. First, that the children were nursed by mothers or wet nurses who exhibited symptoms of adult beriberi; that is, paræsthesia on the feet and finger tips, chest oppression, and constipation. Second, that no medicine was able to effect a cure, in spite of a number of remedies that he tried. In view of these facts, he thought that possibly it was the mother's milk that was at fault, and consequently substituted artificial feeding for breast feeding with which he obtained

gratifying results. With the exception of the aphonia, which lasted for several weeks, the symptoms disappeared with considerable rapidity. The humor improved, vomiting ceased in one or two days, and complete cure was effected within three days. Because of these striking results, he was tempted to conclude that infantile beriberi was an intoxication produced by the milk of beriberic mothers, and that suppression of maternal feeding was the only effective, rational, and causal method of treatment.

However, since the majority of his cases were obtained from out-patients who were being treated in his clinic, his observations were rather incomplete. It was only during the latter part of 1897 (August to November) that he had the chance to observe four patients who were admitted and treated in the hospital ward, the youngest being an infant 1.5 months old, in whom he observed the absence of any motor or sensory disturbances. This important observation enabled him to formulate his classical table comparing the symptomatology of infantile beriberi with the acute cardiac form of adult beriberi. Because of the clear description and masterly presentation of his cases, and the publication of his table in a German medical journal, it soon began to attract world-wide attention.

BERIBERI IN THE PHILIPPINE ISLANDS

Bantug,(7) in his report on mortality statistics in the Census of the Philippine Islands, 1918, volume 2, cites the earliest mention of the disease in Philippine literature. He says, in part:

In describing the Malay Archipelago, Father Colin(8) speaks of beriberi in no uncertain terms. The following, written about 1658, attests to his familiarity with the disease with which he must have become acquainted during his long years of missionary labor in the Philippine Islands. The quotation is given in full:

"The southeast wind is sickly because it comes over the volcanoes of Maquien, Mutiel, and Tidore at the season when the cloves are in bloom and the nutmeg is maturing, and its heat and dryness give rise to many diseases. Particularly the one called Berber, which in some affects the body and extremities, causing the same to swell and paralyzing all the joints, and when this swelling reaches the breast and touches the heart, those who have it die suddenly. In others this disease assumes a dry form, causing the body to dry up and wither from the waist down, until it consumes and kills the patient. The disease is dangerous and practically incurable."

The first epidemic, however, recorded as occurring in the Philippine Islands was that described by Koniger, in 1882. His account is briefly summarized by Herzog(9) in his *Studies in Beriberi*.

PHILIPPINE MEDICAL LORE: EPIFANIO DE LOS SANTOS'S MEMORANDUM

In the Philippines, the existence of the disease had been recognized by native herb doctors under the name of *taong*, or *suba*, as early as the middle of the 17th century. According to a memorandum written especially at my request by the well-known historiographer Epifanio de los Santos, in February, 1910, the word "taong," or "suba," was already included in the Vocabulario de la Lengua Tagala published in 1574 by Fathers Noceda and Sanlucar⁽¹⁰⁾ and the meaning given to it was, "blood rising up into the heart." The same topic was also treated by the Dominican friar Fr. Fernando Santa Maria⁽¹¹⁾ in his popular book, Manual de Medicinas Caseras, which was published in 1768.

The widespread knowledge of this disease is in evidence in the various names and diverse remedies that the natives applied to it; for example, Tagalogs, *taong*, or *taol*, or *suba*; Ilocanos, *til-i*; Pangasinanes, *subi-subi*; Cebuanos, *alferecia*; Pampangos, *taong*; Negros, *masosuelo*; Cagayanos, *til-i* among the Ilocano elements and *alferecia* among the Ibanag inhabitants.

Of the curious and extravagant remedies, the following enjoyed extraordinary popularity. The juice of *ampalaya* or *amargoso*¹ mixed with sugar or honey is to be given to the child immediately after birth until the mother is able to nurse her baby. This they did in order to expel the "bad blood," which they believed the child had sucked in utero. When the infant was attacked by taong, as when it cried unexpectedly, they administered any one of the following remedies: (a) Powdered malaube,² (b) excreta of cockroach, (c) boa's bile, (d) *gasparanton*, (e) *sapagkit*, (f) powdered pearl. These are diluted or mixed with a teaspoonful of the mother's milk. All of these remedies as well as the term "taong" have been carefully preserved as a legacy from generation to generation, and in many secluded barrios such medications are still in vogue.

Til-i was treated, among Ilocanos, by the bile of a chicken, of a lizard, commonly called *bañas*, or of a boa, known as *betlat* among them. They have the custom of preserving the gall bladder, when they kill a chicken, lizard, or boa, by hanging it in a conspicuous place on the wall of the kitchen; usually, the wall facing the stove. They believed that the bile of boa, lizard, or chicken was curative for til-i.

¹ *Momordica charantia* Linn.

² *Aristolochia tagala* Cham.

STUDIES DURING THE SPANISH RÉGIME

During the latter part of the Spanish régime the Excelentísimo Ayuntamiento de la Ciudad de Manila, in its efforts to investigate the cause of the excessively high infant-mortality rate and the amazingly great number of children dying from "taong," in a session held December 14, 1886, approved the holding of a symposium among the members of the "beneficiencia Municipal," on the subject, "Eclampsia, causes which produce the excessive number of infants dying of this disease and means to diminish this mortality." Of the works presented by the seven physicians who participated in it, that of Dr. Manuel Xeres Burgos⁽¹²⁾ was considered the best.

Like the rest of the practitioners at the time, Dr. Xeres Burgos considered "taong" as synonymous with "eclampsia" and "infantile convulsions" and ascribed the high number of children suffering and dying from it to four causes; namely, (a) ignorance of the parents, (b) absence of any notion about hygiene, (c) charlatanism of the quacks, and (d) the custom of not calling a physician until the infants were dying.

Years later, another Filipino doctor, Manuel Gomez y Martinez,⁽¹³⁾ writing on the same subject, concluded that "taong" was nothing more than a mere nervous exhaustion due to gastralgia and intestinal colic produced by digestive disturbances occasioned by faulty feeding.

In spite of all these researches to elucidate the nature of the puzzling problem we remained groping in obscurity and confusion, for until 1904 the Filipino practitioners, with whom I had the opportunity to be in intimate relationship, Manuel Madrigal, Felipe Zamora, and others, still considered "taong" as "infantile convulsions." Even in those days we already noticed cases with aphonia followed by death and loud incessant crying ending fatally; but we did not ascertain its veritable nature, and in our private, confidential conversations we considered the former sometimes as cardiac failure, bronchitis, or pneumonia, and the latter as a form of acute peritonitis.

THE FIRST LINK; GUERRERO'S CLINICAL STUDIES

Then the happy moment arrived that will make the year 1904 a memorable date in the evolution of the medical sciences in the Philippines and one which will recall to memory, whenever the subject of "infant mortality" is touched upon, the name of one of the luminaries of Philippine medicine and to whom the whole country is indebted, Dr. Manuel Guerrero.⁽¹⁴⁾ To him

belongs the honor of having made the first and most acceptable theory on the subject of "taong," for on October 10 of that year, in a meeting of the Colegio Medico-Farmaceutico in Manila, he presented a memoir in which he identified our "taong" with Hirota's infantile beriberi. How he came to this blessed conclusion is vividly narrated in the introductory remarks to a monograph which he and Quintos published in 1910, where he partly said—

. . . obsessed by our excessive infant mortality, and unable to recognize or identify the legitimate nature of the disease which causes it, since its symptomatology did not fit any clinical picture hitherto described in the European infantile pathology, reading an article of Hirota about a disease on breast-fed infants produced by the milk of beriberic mothers, and seeing that the clinical picture of that disease portrayed by the said professor, counterfeits in full our "taong," convinced us that this disease, which until then was vaguely understood in the Philippines, was the beriberi of breast-fed infants observed by Hirota.

Guerrero's article accomplished four important things—first, it established the first basic symptomatic link; second, it produced a complete revolution of our ideas concerning "taong;" third, it paved the way for a new orientation in the study of this malady, and lastly, it renewed our interest in the mystery of this disease.

THE SECOND LINK: ALBERT, MARSHALL AND GILMAN, McLAUGHLIN AND
ANDREWS'S NECROPSIES

Since that time the native doctors began to familiarize themselves with the clinical symptoms of infantile beriberi, and December 4, 1908, the diagnosis of a typical case of infantile beriberi of the cardiac type in a child 3 months old, was corroborated on the necropsy table by the late Harry Marshall and P. K. Gilman;⁽¹⁵⁾ who, besides demonstrating the typical anatomical lesions as already pointed out by M. Miura,⁽¹⁶⁾ of Japan, in 1897, showed further the presence of a degenerative neuritis of the vagus, a further step in our knowledge of this disease, and established its pathological entity. This was the second important link.

Subsequent to this, in the latter part of 1909, the Bureau of Health attempted to confirm by biopsy the clinical diagnosis appearing on the death certificates of infants under 1 year of age dying in Manila. McLaughlin and Andrews,⁽¹⁷⁾ in their *Studies on Infant Mortality*, carefully analyzed the pathological findings in a series of 219 infants dying under 1 year, and demonstrated that of this number, 124, or 56.6 per cent, died of

a condition "which for want of a better term" they designated "moist beriberi."

SKEPTICISM: THE FIRST MEETING OF THE FAR EASTERN ASSOCIATION OF
TROPICAL MEDICINE

Glimpses of the discussion of this paper by McLaughlin and Andrews in the First Biennial Meeting of the Far Eastern Association of Tropical Medicine revealed the skepticism of several prominent members of the delegation present in accepting the conclusion that possibly "taong," or infantile beriberi, was responsible for our high infant mortality. Doctor Musgrave did not believe that infantile beriberi was identical with "taong" and recommended that such a term be held in abeyance; at least, until such time as the etiologic agent and the clinical picture are made more definite. Doctor Clark, of Hongkong, also thought it was premature to term the pathological entity "infantile beriberi" and regarded our "taong," as nutritional in nature, in which Dr. Antonio Sison concurred. Dr. Hans Aron claimed that it is similar to Czerny's Mehlarschaden or carbohydrate intoxication.

GUERRERO AND QUINTOS'S AND ANDREWS'S MONOGRAPHS

In the meantime Guerrero and Quintos,⁽¹⁸⁾ to complete and to corroborate further their memoir of 1904, studied additional cases, which culminated in the presentation of a monograph published in Manila in 1910 with the title, *El Beriberi en los Niños de Pecho*. The study comprised one hundred seventy-two cases with two autopsies performed twenty-two and thirty-two hours after death, respectively. In this work the authors discussed completely and in a masterly way the clinical and anatomical manifestations of the disease as well as the various therapeutic agents that filled the physician's armamentarium at that period. Furthermore, they reaffirmed Hirota's view that infantile beriberi is the result of an intoxication produced by the milk of beriberic mothers, and that the best method of treatment is the suppression of breast feeding.

Andrews,⁽¹⁹⁾ in 1912, working independently, studied the manifestations of beriberi in both the mother and the infant, followed immediately by necropsy. He based his diagnosis of infantile beriberi on four points; namely, (a) cardiac dilatation and hypertrophy, (b) congestion of the viscera, (c) anasarca, and (d) absence of any other findings to account for the death.

In his conclusions, Andrews believed that infantile beriberi was due neither to bacteria in the milk nor to an infection or

toxæmia of either the mother or the child, "but to something lacking in the mother's milk which is essential for the growth of the nerves of the child." Working on this hypothesis he attempted to reproduce the disease by feeding puppies with the milk of mothers whose children died of beriberi, and claimed to have succeeded in reproducing the disease in these animals.

THE THIRD LINK: CHAMBERLAIN AND VEDDER'S TIKITIKI EXTRACT

While the works of Van Leent, Fraser and Stanton, Strong and Crowell, Eijkman, Funk, Andrews, and others pointed to the deficiency nature of the disease, it remained for Chamberlain and Vedder⁽²⁰⁾ to give the last and decisive proof against the old "intoxication" theory of its etiology. It should be stated that previous to Chamberlain and Vedder's studies, native physicians, influenced by the works of the above-mentioned authorities, treated their beriberi patients by administering large quantities of rice polishings to the mother and weaning the child at the same time, a method open to many serious objections; among them, (a) it unnecessarily subjects the infants to all the dangers that attend artificial feeding; (b) the difficulty of providing proper canned or fresh milk, as the majority of these cases were of the very poor class; (c) no conclusion can be arrived at, since weaning alone produces a cure, as was first shown by Hirota; and (d) it is difficult to administer rice polishings because of its unpleasant taste, and it is absolutely impossible to feed it to infants.

Chamberlain and Vedder, convinced that beriberi was due to a deficiency and not to an intoxication, thought that the suspension of lactation was unnecessary, provided that the missing substance can be supplied artificially. In accordance with this belief they determined to treat cases of infantile beriberi by administering the extract of rice polishings directly to the infant while permitting it to continue nursing its mother.

The infants were all given twenty drops of the extracts of rice polishings every two hours while awake, until 5 cubic centimeters was consumed in twenty-four hours, which is equivalent to 82 grams of rice polishings. The results have been truly marvelous. Improvement was immediate. Vomiting stopped in twenty-four to thirty-six hours. The dyspnoea and palpitation ceased after two or three days; urination became normal; the aphonia, however, did not disappear until after about two months of treatment.

Inspired by these excellent results, they said that this extract is a "cure" in the true sense of the word, just as lime

juice is a "cure" for scurvy, and that it acts with as great promptitude as does fruit juice in infantile scorbutus. They regarded their work with infantile beriberi as the final link in the chain of evidence that has been built up from experiments on men and animals, and which proves that an improper diet, usually one consisting mainly of highly milled rice, is responsible for the development of beriberi.

EXTENSIVE TRIAL OF TIKITIKI EXTRACT BY THE LIGA NACIONAL FILIPINA

Following this discovery, and on account of the high infant mortality, the Philippine Legislature appointed a committee to investigate and to adopt measures that would tend to diminish this rate. Early in 1914, this committee submitted its report wherein infantile beriberi was ranked first in importance in the mortality and morbidity of the Islands. In the same year, the Segunda Asamblea Regional de Médicos y Farmacéuticos de Filipinas presented a resolution to the Philippine Legislature which was converted into the Angeles Act approved February 28, 1914, appropriating a certain sum of money for the preparation and free distribution of tikitiki extract to the poorer classes. The preparation was entrusted to the Bureau of Science in Manila, and the Liga Nacional Filipina para Protección de la Primera Infancia was appointed custodian and distributor.

The island-wide campaign against this disease might be gleaned from the figures contained in the fifth report of the Liga Nacional, 1918,⁽²¹⁾ and the heavy output of tikitiki extract from the private laboratories of Zamora, Hizon and Rodriguez, and others. From October 16, 1917, to October 15, 1918, the Bureau of Science alone supplied 8,019 bottles, 50 cubic centimeters each, and 150 ampules, 1 cubic centimeter each, of tikitiki extract, which were distributed free in various provinces and in the City of Manila. The results were commensurate with the money spent, for the percentage of deaths among infants was markedly reduced as may be seen in Table 1.

TABLE 1.—*Cases of infantile beriberi treated and percentage of deaths, 1914 to 1918.*

Years.	Cases treated.	Percentage of deaths.
1914 (June 15 to October 15)	72	15.2
1914 to 1915 (October 16 to October 15)	273	1.09
1915 to 1916 (October 16 to October 15)	272	1.4
1916 to 1917 (October 16 to October 15)	524	0.76
1917 to 1918 (October 16 to October 15)	350	0.79

It is not too alluring to say that such results fulfilled our prediction in 1916 that theoretically no child attacked by infantile beriberi should die if treated early and properly.

In 1918, after such an extensive trial and conclusive results, La Liga Nacional submitted its fifth report to the Legislature with this conclusion:

For all that has been presented this body believes and thinks that the period of *trial and experimentation* in the treatment of infantile beriberi with the extract of tikitiki, can be said to have concluded, and that this remedy discovered in 1911 by the American doctors, Chamberlain and Veder, administered in convenient doses is the drug most effective and sure which medicine counts on to-day to combat this terrible disease which pays a high toll of innocent breast-fed infants yearly in Manila and which is responsible for about 30 per cent of the infant mortality. In this respect it can be affirmed that the resolution presented by the "Segunda Asamblea Regional de Médicos y Farmacéuticos de Filipinas," converted into Angeles Bill . . . is one of the most beneficial laws and is of immense significance for the future of the Filipino people since that law tends to solve in part the problem of infant mortality and depopulation.

It is no vainglory to say that it was only extensive clinical observations and untiring efforts in experimentation that made possible the fitting of the three important links—symptomatic, pathological, and etiological—in the chain of study of this disease with such happy result. Twelve years after the experimentation by the Liga Nacional, with continuous trial and researches, we are reaping its bountiful harvest; namely, the reduction of our infant mortality to about one-half, and the diminishing incidence of beriberi to such an insignificant number that because of its rarity many physicians, especially the younger ones, are losing the clinical picture of this disease.

THE FOUR EVIDENCES: PHILIPPINE GENERAL HOSPITAL, PHILIPPINE HEALTH SERVICE, PUERICULTURE CENTERS, MEDICAL PRACTITIONERS

From a corner in the children's ward of the Philippine General Hospital we have silently observed the uninterrupted effects of this discovery; the slow but steady diminution in the number of infants suffering from infantile beriberi, a diminution which inspired us to write our article, "Is infantile beriberi disappearing?" (22) The figures in Table 2, from the pediatrics ward of the hospital, clearly demonstrate this marvelous result.

This observation of ours is confirmed by the figures obtained from the office of vital statistics of the Philippine Health Service which are given in Table 3.

TABLE 2.—Total infantile beriberi and percentage in relation to total admission under one year and all ages, by years, in pediatrics ward, Philippine General Hospital, College of Medicine, University of the Philippines.

Year	Total admissions of infantile beriberi.	Total admissions of under 1 year.	Percentage of infantile beriberi to total admissions under 1 year.	Total admissions of all ages.	Percentage of infantile beriberi to total admissions of all ages.
1914.....	51	328	12.50	547	9.32
1915.....	45	304	14.80	577	7.79
1916.....	52	336	15.47	591	8.79
1917.....	51	422	12.08	866	5.89
1918.....	40	403	9.92	1,127	3.55
1919.....	24	344	6.97	792	3.03
1920.....	37	441	8.39	1,091	3.39
1921.....	39	348	11.20	1,171	3.33
1922.....	37	440	8.40	1,030	3.59
1923.....	46	378	12.16	1,276	3.61
1924.....	19	540	3.51	1,369	1.39
1925.....	18	558	3.22	1,383	1.30
1926.....	9	640	1.40	1,408	0.64
1927.....	6	573	1.04	1,316	0.46
1928.....	6	582	1.03	1,344	0.45
1929.....	19	703	2.70	1,573	1.15
1930.....	15	823	1.82	1,712	0.88
Total.....	514	8,163	6.29	18,173	2.82

TABLE 3.—Total births and deaths in relation to cases of and deaths from infantile beriberi, from the Philippine Health Service.

Year.	Total births.	Total deaths under 1 year.	Infant-mortality rate per 1,000 births.	Death from infantile beriberi.	Death rate from infantile beriberi per 1,000 births.
1914.....	9,599	3,325	346.39	899	93.66
1915.....	8,850	3,511	396.72	1,058	119.55
1916.....	9,082	3,059	336.82	805	88.64
1917.....	8,883	2,447	275.47	384	43.23
1918.....	9,083	3,611	397.56	597	65.73
1919.....	10,029	2,256	224.95	354	35.30
1920.....	12,614	2,687	213.02	555	44.00
1921.....	12,261	2,871	234.16	722	58.89
1922.....	13,092	2,543	194.24	671	51.25
1923.....	14,598	2,804	192.08	739	50.62
1924.....	13,969	2,733	195.65	664	47.53
1925.....	15,046	2,513	167.02	616	40.94
1926.....	14,813	2,463	166.27	538	36.32
1927.....	15,386	2,313	150.33	280	18.20
1928.....	15,709	2,378	151.38	360	22.92
1929.....	16,098	2,762	171.57	553	34.35
1930.....	16,581	2,657	160.24	317	19.12

As may be clearly seen, while in 1914 the infant-mortality rate from all causes was 346.39, in 1930 this was reduced to 160.24, and the mortality rate from infantile beriberi, which was then about 93.66 in 1914, was reduced to 19.12 in 1930. The decline in these rates may be seen in the accompanying graph.

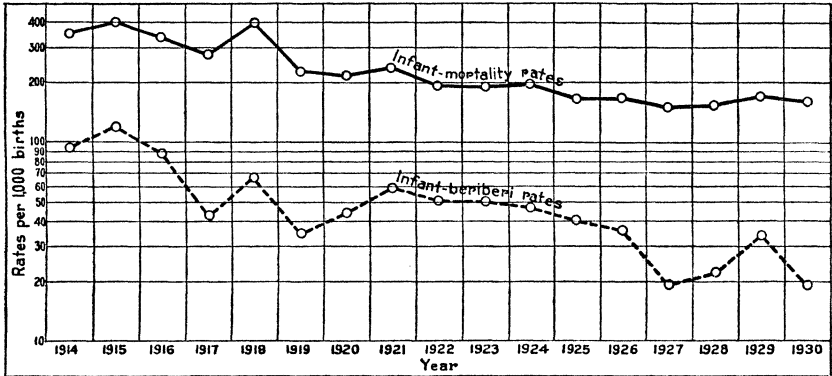


FIG. 1. Infant-mortality and infant-beriberi rates per 1,000 births (transients included) in the City of Manila by years.

The same phenomenon has been observed in the various puericulture centers that are strategically located in the different parts of the city as shown in the following statistics furnished by Dr. Tranquilino Elicaño.(23)

TABLE 4.—Number of infants under 1 year in relation to number of beriberi cases admitted in different centers and number of bottles of tikitiki extract distributed.

[Table from the office of the Public Welfare Commissioner.]

Year.	Admission under 1 year.	Beriberi cases.		Bottles of tikitiki extract distributed.
			Per cent.	
1923.....	3,735	1,127	30.17	9,960
1924.....	5,097	837	16.22	12,198
1925.....	5,644	434	7.68	12,153
1926.....	5,634	124	2.20	13,553
1927.....	6,501	165	2.54	15,932
1928.....	7,003	132	1.88	17,055
1929.....	6,787	121	1.78	17,149
1930.....	7,245	173	2.39	13,174
Total.....	47,646	8,113	6.53	111,174

Dr. T. Elicaño, in his letter of transmittal, remarks of this table: "The number of admissions in the puericulture centers (in the city) increases yearly, while the beriberi cases decrease notably and are *proportional* to some extent to the number of bottles of *tikitiki extract distributed*; the same technical personnel continued in charge of those puericulture centers, so that the factor of appreciation from the point of view of diagnosis is eliminated practically."

The private medical practitioners in the city when questioned about the frequency of infantile beriberi, entirely agree that this old scourge is becoming rarer every day.

RÉSUMÉ

Briefly summarized, we find that after twenty-seven years, beginning from the memorable conference of October, 1904, by the late and eminent Manuel Guerrero, nineteen years after the glorious publication in 1912 of its specific remedy by Chamberlain and Vedder, this implacable and wanton enemy of breast-fed infants is now wane-ward bound. As a result of these two admirable events we will notice that while in 1906 our infant-mortality rate for the City of Manila was 476.17, to-day (year 1930) it is only 160.24. This diminution is due mainly to the reduction in the mortality from infantile beriberi, which, without the least shadow of doubt, has been successfully fought by tikitiki.

Such scientific success, within such a relatively short period, is seldom registered in the annals of medicine, a conquest beneficial both to the Philippines and to the scientific world because of its fundamental bearing on the problem of the treatment and control of functional, reversible changes of cardiac failure.

ETIOLOGY: CONSTELLATION OF CAUSES

LORD MOYNIHAN'S SENTENCE

In considering the causation of infantile beriberi, we must bear in mind that Lord Moynihan⁽²⁴⁾ aptly said, "Events in medicine are rarely dependent upon the solitary cause, and Medicine is perhaps distinguished from all other sciences, not only by the number and interaction of possible causes, but by the remoteness, apparent irrelevancy or obscurity of causes whether immediate or proximate." Infantile beriberi is a disease in which exists a veritable constellation of causes, each and every one of which has its own relative value. These diverse factors in the production of infantile beriberi are the following:

SEASON AND CLIMATIC CONDITION

Humidity, rainfall, temperature, and atmospheric pressure, undoubtedly exert some influence. As may be seen in our monthly tabulation, beriberi comes under observation oftener during the rainy than the dry season, and although it occurs throughout the year, it begins to increase in August, reaches its maximum in December, and gradually declines until July. In Japan the greater number of infantile beriberi cases is observed from May to October, more particularly in July and August. Ohta⁽²⁵⁾ claims that there is no uniformity in the yearly incidence and mortality. In some years cases and deaths from beriberi are more than in others.

REGIONAL DISTRIBUTION

I have the impression that in the Philippines the regions that are heavily punished by beriberi at the present time are the urban communities, which are densely inhabited and where living conditions are in marked contrast with those of the rural districts. In my short survey in the Bicol provinces in 1913 and occasional investigations in Tayabas and Nueva Ecija Provinces, I felt that many cases recognized as beriberi are not genuine beriberi. A more careful and conscientious study of this subject is imperative, in as much as observers in other countries where beriberi is endemic, notably R. McCarrison,⁽²⁶⁾ have pointed out that even in countries where milled rice is the staple food, it is only in certain localities that beriberi is met with. Furthermore, people living in nonendemic regions seem to acquire a potentiality which predisposes them to beriberi when they are transferred to endemic places, a potentiality which they carry with them on returning to nonendemic areas.

RACE

Infantile beriberi is never observed among Caucasians and is seldom observed among the white half-breeds; this has no explanation except the difference in the diet and the mode of living.

AGE

The effects of food deficiency are variable according to the age of the subject. Scurvy, for example, is observed during ages of 6 to 18 months; rickets between 3 months and 2 years. In infantile beriberi the younger the child the more frequent and the more severe the disease is.

As can be seen from the figures in the accompanying table, the most dangerous period belongs to the age group of 1 to 3 months

(30 to 120 days), comprising about 53.69 per cent of the cases. Following closely is that from 3 to 6 months; then from 6 months to under 1 year; 1 week to 1 month and, lastly, from 0 to 1 week. Fifty per cent of Professor Ohta's four hundred thirty cases belong to the age of from 2 to 3 months.⁽¹⁸⁾ Guerrero and Quintos said, "Beriberi is a disease which only affects infants who do not reach the first year of life. The greater number corresponds to the age between one and three months." Of the different clinical types we have observed, that of the cardiac and aphonic forms occur generally before the fourth month, while the pseudomeningitic is more frequently met with after that age.

Congenital beriberi or the one occurring during the first week of life is exceptionally rare. It occurred only four times in our series of five hundred fourteen cases. Ohta saw it but once out of four hundred thirty cases and remarked: "In infants less than one month old, diagnosis is extraordinarily difficult, inasmuch as the symptoms are not quite distinct, and I was able to precise my diagnosis of beriberi but once and that was in an infant nine days old."

SEX

Guerrero and Quintos believe that there is some predilection for males, but according to my tabulation of five hundred fourteen cases, both sexes are affected in about the same proportion. The Japanese authors agree with Ohta that the proportion for females and males is 1:1.6 to 1.9, or the frequency in males is almost double.

SOCIAL AND ECONOMIC CONDITIONS

Infantile beriberi is strikingly a disease of poverty, occurring very exceptionally among the rich and middle classes, so that physicians practicing among them may deny its existence. Ohta also believes that it is more prevalent among those belonging to the "lower strata of society."

Economic condition in itself is not certainly the cause of the disease, but it is the indulgence in a faulty unbalanced diet in the great majority of cases. Beriberic mothers belong to those people whose "food habits" are controlled by custom and prejudice. This faulty feeding leads to some deviation of the body fluids, milk included, from the normal constitution. The nursing mothers of the "lower strata of society" generally indulge

in a monotonous diet, which consists mostly of dried fish and an excessive amount of rice but is very poor in vegetables. According to McCarrison⁽²⁶⁾ this kind of diet has at least five faults; namely, poverty in protein, excess of starch, deficiency of certain minerals (calcium, sodium, and chlorine), and deficiency in vitamins A and B.

CONSTITUTION, "STATUS PASTOSUS" MOURIQUAND AND BERHEIM

Internal and hereditary factors are very important in the production of infantile beriberi, in consonance with the modern but fruitful constitutional doctrine which faded before the etiological promise of bacteriology with its exclusive external causes. In fact, formerly we ruled out the diagnosis of beriberi in those infants whose constitutions do not exhibit the seemingly trivial "plump" appearance recently termed by Mouriquand and Berheim⁽²⁷⁾ "status pastosus," which is equivalent to "lymphatism" or to "branchimorphic, megalosplanchnic" of Pende or Czerny's "exudative diathesis." Status pastosus is described as, "a particular state of nutrition with anemia, hyperhydration, linked frequently with spasmophilia and in some cases with rickets, a soil particularly favorable to sudden unexpected death," as it happens in cardiac beriberi. "Megalosplanchnic" is also defined as "characterized by the relative preponderance of the vegetative system in relation to the development of the system of the life of relation."

The great authority on adult beriberi, Scheube,⁽³⁾ believed that 87 per cent of cases of beriberi occur in robust individuals, and in my observation infantile beriberi occurs in no less percentage in infants of "plump" appearance, and overfed rather than underfed. I generally hold that the mere presence of "hypotrophic" condition should put us on guard for further examination and revision of any diagnosis of infantile beriberi in them.

ASSOCIATED DISEASES

Shimazono,⁽²⁸⁾ in discussing the etiology of adult beriberi, pointed out that certain infectious diseases, such as influenza, typhoid, and tuberculosis, and certain chronic conditions, as anemia, diabetes, and nephritis, are commonly associated with beriberi. In infants we have not observed any particular relationship between beriberi and any other disease, except bronchitis and bronchopneumonia which we found to have been, in some cases, in association with beriberi. Hirota found that sixteen of his early thirty cases were associated with bronchitis, intes-

tinal catarrh, scabies, bronchopneumonia, or eczema. Quintos and Guerrero, in their monograph, classified infantile beriberi into pure and mixed forms, the latter being associated with gastroenteritis, bronchitis, or convulsions.

BREAST FEEDING

All medical observers unanimously recognize the fact that breast feeding is the condition "*sine qua non*" (Guerrero and Quintos) for the production of infantile beriberi, and in my practice I do not remember having encountered a single case of infantile beriberi in an infant that was never breast fed by the mother.

It is true that in medical literature we read from time to time reports on cases of infantile beriberi in bottle-fed babies. Chapman(29) reported eight such cases in 1927. Ohta(25) claims to have seen sixteen among his four hundred thirty cases, and in the last three years we have gathered four cases of infantile beriberi in infants, who at the time of admission were not nursed by the mother's breasts. It should be emphasized here that the occurrence of these rather exceptional cases cannot, and should not, be construed as derogatory to what we have stated above, that breast-feeding is the condition "*sine qua non*;" because, in penetrating deeply into the feeding history of all these cases, we shall always be able to point out that these infants were nursed by their mothers, some time after birth and before the manifestations of beriberi in them. The history records of our four cases clearly demonstrate this striking fact:

Case 1. Infant, 6 months old, artificially fed at the time of admission for four months, but breast fed for the first two months.

Case 2. Infant, 9 months old, artificially fed for the last seven months, but breast fed for the first two months.

Case 3. Infant, 1 year old, artificially fed for almost a year, but received mother's milk during the first week of life.

Case 4. Infant, 8 months old, mixed-feeding.

Guerrero and Quintos, in discussing the kind of feeding, unconditionally upheld that, "Only a cursory and insufficient investigation or erroneous attitude on the part of the physicians may induce them to believe in the existence of infantile beriberi in artificially-fed infants." In support of this dogmatic assertion they presented the three following observations which are translated here in detail:

In the month of January of this year (1910), one of us (Quintos) was called to see a five-month old child, at Lara street; and he was found to have all the symptoms of hyperacute beriberi. The mother was asked of

its feeding, and he heard with surprise that the little sick one was bottle-fed. It was hard to believe this, because it was in opposition to his daily experiences; but inasmuch as the mother swore that the food of the child consisted solely of condensed milk and nothing else, there was nothing to do but believe it, recording it in his memorandum as the first case of beriberi acquired not through maternal feeding. This child died. A few days later, this same physician went to visit a child in the contiguous house, who was nursed by the mother and attacked also by beriberi. Upon hearing this diagnosis, the mother exclaimed, "Therefore the sickness of my child is the same as the one that killed the child of my neighbor!" "How do you know it, madam?" asked Dr. Quintos. "Why not, since I gave my breast to that child two times when one night it was left to my care?" At last was found the cause of that beriberi, which otherwise would have been an argument against that which up to the present time has been traditionally observed, that infantile beriberi is encountered only among breast fed infants.

The second case was observed by M. S. Guerrero. To a female twenty-six-day-old child, an acute attack of "taon" came on October 3, 1908, preceded for about nineteen days by incoercible vomitings, restlessness, taquipnea, aliguria, etc. Guerrero was then called to see her, and to withdraw her from her mother's breast, she was inscribed in "Gota de Leche" for artificial feeding. With this, the symptoms improved, and the child seemed to be in full convalescence, when one night Guerrero was again urgently called, because the little girl was again under an attack. The return of the malady greatly astounded him. He asked the mother whether, following the advice given her, she abstained giving the breast; and she assured him that she had, and that since the child was enrolled in "I.a Gota" the infant did not receive any other food except cow's milk. Reminded, however, of the custom of our mothers to sleep by the side of their children, he asked her some more questions, and the woman confessed that on several occasions, when she happened to wake up at night, she found her child peacefully sucking her breasts. We came to find out again the cause of an attack of beriberi in an artificially fed child.

There can exist, therefore, no doubt as to this etiological factor. And if we are still required to give more proof, we can relate another case which has the value of a laboratory experience.

The wife of the janitor in one of the banks in this capital acquired beriberi during her pregnancy, and gave birth to twins, a boy and a girl. To the boy she gave condensed milk, and to the girl her breasts. Fifty-two days after birth, or, on July 8th, 1907, the girl suffered from a hyperacute form of "taon" and died. The boy, on the other hand, fed artificially, developed perfectly, without having had any symptoms of beriberi.

PECULIARITIES OF THE CAUSAL RELATIONSHIP BETWEEN MOTHER'S MILK AND INFANTILE BERIBERI

In analyzing the causal relationship between infantile beriberi and mother's milk three puzzling peculiarities should be noted.

1. That the severity of the disease in infants is not directly proportional to the severity of beriberi in the mother. Most of the fatal cases of infantile beriberi come from mothers with

the rudimentary form of the disease and vice versa. There are cases of severe maternal beriberi without affecting the offspring.

2. Notwithstanding the absence of either objective or subjective symptoms of beriberi in the mother, beriberi is observed in infants in a great number of cases. I agree with Ohta's estimate that about 25 per cent of the cases are of this type. In my own judgment, this phenomenon of "symptomless" beriberi in the mothers has no other explanation than what Charles Nicolle and Charles Lebailly (30) call "infection inapparent," as applied to the apparently symptomless phase of some infectious diseases, which can be detected with improved technic, and which occurs naturally and plays an important part in the spread and prolongation of an epidemic. Likewise, these mothers are true beriberi subjects, in which the beriberi is in the "inapparent phase."

More recently, Mouriquand (31) calls attention to what he terms "inapparent dystrophies" (*les dystrophias inapparentes*) or "symptomless dystrophies." He said that in experimental scurvy there exists a trophic coefficient peculiar to each individual animal, which may produce either a manifest (with symptoms) condition of deficiency (*carence*) or a symptomless state of predeficiency (*pre-carence*); and the latter can be detected by means of new and improved technic.

The existence of many of such cases of "inapparent" beriberi in mothers (without objective or subjective symptoms) is supported by daily observations here and abroad. I have seen mothers in whom the symptoms of beriberi began to be manifest some time after their children had died of infantile beriberi. Hirota, of Tokyo, in his second communication, mentioned three cases in which the manifestations of beriberi in the mother were retarded fourteen, twenty-nine, and thirty-two days, respectively, after its appearance in the infant. What is at fault, I believe, is the lack of a minutely conducted examination, or the lack of improved methods and technic to detect the symptoms. Guerrero and Quintos, in this connection, emphatically said, "And in reality, if we will not lose sight of many of these cases, surely we will witness the development of the disease whose manifestations were *latent on the day of the examination*."

3. That the production of beriberi is independent of the duration of breast-feeding from beriberic mothers. We have seen and treated cases of infantile beriberi in which the history of breast-feeding was of comparatively short duration. One of

our four bottle-fed cases previously mentioned, gave a history of having been breast-fed for only one week, and the cases mentioned above by Guerrero and Quintos were breast-fed for very short periods.

EXPERIMENTAL BERIBERI

Andrews⁽¹⁹⁾ performed an experiment, trying to reproduce beriberi by feeding seven young puppies, 2 to 14 days old, with milk of beriberic mothers for a period of one month, in order to determine that beriberic milk is probably deleterious by reason of what it lacks rather than because of any harmful constituent. Andrews summarized the results of the experiment as follows:

All of these puppies showed incoördination and weakness of the extremities, particularly of the hind legs. In all slight degeneration of the peripheral nerves by the Marchi method was demonstrated. All showed œdema and anaemia of the subcutaneous tissues. These findings agree entirely with those of the infants dying of beriberi. However, only one of the puppies showed the dilatation and hypertrophy of the right heart which I have regarded as a constant finding in infantile beriberi. In my opinion these experiments furnish, therefore, additional evidence that the condition described as infantile beriberi is due simply and solely to the ingestion of the mother's milk.

This experimental beriberi indicates that beriberi in infants differs in many respects from animal beriberi, and the clinical observations confirm this distinction, in as much as we never observed incoördination and weakness of the extremities, and that the heart, in infants, is particularly the organ severely affected.

DEFICIENCY DOCTRINE

In order to explain the action of the milk of beriberic mothers in the causation of beriberi, it was believed, since Hirota's time, that infantile beriberi was due to an intoxication, but this theory gradually weakened because of the failure to demonstrate the presence of such a mysterious toxin and, finally, it was completely abandonéd, with the discovery of the extract of tikitiki, its specific remedy with which infantile beriberi is rapidly cured without resorting to weaning. We feel that it is unnecessary to discuss the infectious theory due to *B. mycoides* and *mesentericus* of Jose E. Montes,⁽³²⁾ which he claimed to have obtained from the liver, bone marrow, and pleural fluid of beriberi patients and with which he produced the disease in animals by inoculation of these organisms, for the simple reason that such microörganisms were never demonstrated to be present in human milk, nor have confirmatory findings been made by other investigators.

Furthermore, the whole clinical process and treatment of infantile beriberi do not present any evidence that it is of an infectious origin.

Based upon experimental medicine and clinical observation, we believe that infantile beriberi is a true deficiency disease, in the sense that beriberi milk lacks vitamin B, a "hormone food" or "functional food," which is indispensable to the preservation of a proper "internal medium" and normal physicochemical metabolism.

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ILLUSTRATION

TEXT FIG. 1. Infant-mortality and infant-beriberi rates per 1000 births
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INDUSTRIAL SHELLS OF THE PHILIPPINES

By FLORENCIO TALAVERA and LEOPOLDO A. FAUSTINO

Of the Bureau of Science, Manila

EIGHTEEN PLATES

Shells of Philippine mollusks have been put to many and varied uses since the earliest times. Before the Spanish occupation no specific mention regarding the use of marine shells for ornaments and in trade and barter has come to the attention of the writers, but it is not difficult to imagine that they were used as ornaments or in exchange for other things as was the custom in some of the islands in the West Pacific.

The accounts of early Spanish historians have references to the uses made of the different shells. About 1570, the natives of Mindoro were blowing horns made of shells.¹ Species of *Tridacna* have been mentioned as used for a watering trough and as a holy-water font. From the same shell some of the people were supposed to have made saws, which they sharpened by rubbing the shells against certain stones. Other uses of shells mentioned are as drinking cups, tweezers, censers, and others of general character. The inhabitants of Camarines Provinces used helmets set with fishbones and stout shells. Those in Zambales used shells as marks of distinction, those who had killed more than nineteen persons wore certain very highly colored *sigueyes* (shells). It is recorded that the early inhabitants made use of shells as a medium of exchange, as tribute offerings, as ornaments, as a source of lime, as panes for windows, and as a source of pearls.

¹ Most of these historical references are taken from E. H. Blair and J. A. Robertson. *The Philippine Islands*. Clark, Cleveland, Ohio (1903-1909) 8°, 55 vols.

At the present time large *Tridacna* shells are used in many churches as holy-water fonts. Some of the Batan islanders use certain kinds of miter shells for pipes. Fishermen in the Visayas occasionally use shells to make clarion calls. The present report, however, will deal only with those shells used on a commercial scale, and that are gathered in sufficient quantities to enter into our commercial statistics. These shells are the pearl shells, the trochus shells, the turban shells (all used for button making), the window shells, and the pearly nautilus.

The information given in this paper, particularly regarding the life histories and habits of these mollusks, has been compiled from the personal notes of the writers and from all available literature. The articles in the Philippine Journal of Science have been freely used. Due acknowledgment is hereby made to the various authors consulted.

The writers also wish to acknowledge with thanks the help extended and courtesies shown them by the shell factories in the City of Manila and by the shell dealers in the provinces.

GOLD-LIP PEARL SHELL (PLATE 1)

Common names: Pearl oyster, pearl shell, gold edge, gold lip, silver lip.

Local names: *Concha blanca* (Sp.), *concha* (Tag.), *tipay* (Vis.), *tipay bas* (Tausug).

Trade names: Manila, Sulu, Singapore, Port Darwin, West Australian, Queensland, New Guinea, Mergui, Macassar (Sydney or Aroes).

Scientific name: *Pinctada maxima* (Jameson)=*Margaritifera maxima* (Jameson)=*Meleagrina maxima* (Jameson)=*Pteria maxima* (Jameson).

DESCRIPTION

Shell orbicular, thick, massive, flatly convex, margin rounded except on the side of the hinge, where it is straight. Exterior concentrically laminated, laminæ produced towards the margin into lappetlike processes, forming more or less irregular twisted scales, fragile and rather transparent. Color pale yellowish brown with traces of radial markings of other colors. Interior light golden brown, nacre silvery white, lustrous, with a broad golden border, and plenty of "fire" (many-colored iridescence).

The shell figured has the following measurements: Height, 20.5 centimeters; breadth, 20.5; diameter, 4.2; length of hinge, 13.

OCCURRENCE AND DISTRIBUTION

The gold-lip pearl shell is widely distributed throughout the Philippine Archipelago, occurring in waters from 5 to 40 meters in depth. It is more or less abundant in certain localized areas. The region from Basilan to Borneo, comprising the entire Sulu Archipelago, is one extensive pearling bank, covering an area of about 35,000 square kilometers, the largest and the most prolific in the Philippines. Natural beds exist in Davao Gulf, Illana Bay, Mindanao; at Cagayan Sulu, Palawan, Cuyo, Bohol, Cebu, Bantayan, Masbate, Ilacaon, Gigantes, and Guimaras Islands; New Washington, Balasan, and Estancia, Panay; Masinloc Bay, Zambales; on the western and northern coasts of Samar; and around Cape Engaño, Polillo Islands, and the Batan group.

Life history and habits.—The gold lip inhabits warm seas, from 5 to 120 meters in depth, where the ocean currents are strong and where the water has a specific gravity of about 1.022 and a temperature of from 23° C. to 35° C. It thrives well in clear water on suitable bottoms of sand or coarse gravel with dead corals or rocks or ooze formed by the deposits of foraminifera and globigerina, with growth of eel grass and other submerged plants. Except during the larval period, the oyster is more or less stationary, although it is not uncommon to find it removed through such agencies as tidal currents or man, rather than through its own power of movement. It can move about for several centimeters only by casting off the organ of attachment and using the foot.

The sexes of this species are distinct and separate; that is, the individual is either male or female. The mature female produces several thousand eggs. These when ripe are discharged into the sea water to be fertilized by the male element. The meeting between the reproductive substances is left entirely to chance. The eggs are pear-shaped and buoyant at first, becoming rounded after fertilization, and thereafter the resulting trochophores develop cilia that enable them to swim and drift. During this stage the young are in great danger. They are exposed to the mercy of tides, currents, winds, and waves that may carry them away from their paternal habitat. In about forty-eight hours the larvæ reach the veliger stage and develop shells; and in from four to five days they settle down or set on any object upon which they chance to fall. The shelled larvæ are now known as spat and are about 1 centimeter in length. Hairlike bristles, collectively called the byssus, appear with

which the young oysters are enabled to anchor themselves to any hard object. If attached to floating material, they seek the under or shady side, as they are highly sensitive to sunlight. Soon they drop off and sink and then adhere to any resisting object by means of the byssus. A single thread of this organ is sufficient to insure fixation.

The growth rate of the gold lip is fairly rapid in the Philippines. In the Sulu Archipelago it is sexually mature in two years and has been observed to spawn during the months from May to September, although it seems capable of performing the generative functions at every season of the year. The frequency at which it emits sexual products within the period of one year in any one particular locality in the Philippines has never been ascertained. It is probable that there are periods during which the spawn are more abundant than at other times and that spawning does not occur at the same time in all the islands of the Philippine Archipelago, nor even in all islands of one group, such as, the Sulu Archipelago or the Bantayan group. In three or four years, when it is most valuable commercially, the gold lip attains a size of from 18 to 23 centimeters in its greatest outside long-axis measurement; that is, the distance from the hinge to the lip. At this age the nacre measurement taken at right angles to the hinge is at least about 14 centimeters, the minimum legal size limit for this species. Under favorable conditions a mature oyster may in less than three years overreach this requirement. The maximum age and size of the gold lip are not very well known. Large specimens have been secured now and then that most probably are more than 10 years old. These are generally worn out, encrusted with sponges or badly riddled by boring mollusks and worms.

No artificial cultivation of pearl oysters or pearls is conducted anywhere in the Philippines. The Sulu Archipelago and the Bantayan Islands have sheltered recesses where pearl shells may be transplanted and cultivated or cultured for pearls. For this purpose, concessions should be granted to be leased for say ten or twenty years, with adequate protection by the Government; otherwise, it would be extremely difficult to carry on the experiment successfully, as such farms are always exposed to harmful attempts on the part of the misguided, ill-intentioned element of the community. The cultural method used successfully in Japan could be profitably carried on, if properly developed and protected, in certain favorable localities in the Philippines. Preliminary experiments on culture pearls conducted by Mr.

Kashiwagi in 1929 in the water in front of the town of Jolo revealed significant and encouraging information on the comparatively rapid growth of nacre around the inserted shell nuclei. Spherical shell beads 5 millimeters in diameter were introduced into the soft parts between the mantle flaps of 2-year-old gold-lip oysters. The operation is very delicate, requiring skill and a thorough knowledge of the anatomy of the vital parts. The treated mollusks were placed in wire baskets and lowered into the channel near the town of Jolo and were inspected every month. In the course of inspection it was discovered that the wire baskets were disappearing gradually. Since these were adequately weighted against the currents in the channel, the reason for their disappearance was, therefore, not very difficult to find. The experiment was exposed to human depredation, but could have been carried on to a more successful conclusion if properly protected. However, in shells that were recovered after thirteen months the beads were coated with nacre and appeared as perfect as any natural pearls, with a bluish luster. The shell beads had increased in diameter from 5 to 7 millimeters. This information seems to indicate that culture pearls can be grown successfully in the Philippines, and if properly handled and adequately protected the cultural farms could be made a source of considerable revenue.

From the fertile grounds of Mindanao and Sulu in particular, and from the northern beds in general, pearl shells are obtained by skin and armored divers. The former work from native dugouts (vintas or bancas), and the latter from luggers. Formerly, one-masted pearling yachts were in common use, but at present, the two-masted types are more generally employed. Practically all are motor boats with engine air pumps. The boats range from 8 to 16 tons in gross tonnage and usually carry a crew of eight or nine men; namely, the captain, the supercargo, two divers, one or two engine men, a cook, and two or three sailors. The supercargo is generally the owner of the boat himself or his representative. In smaller luggers the captain is also one of the divers. Generally, when operating, the boat is not anchored, and since the work is done at the slack of the tide, she can be managed to float practically at a standstill. In places where the current is strong it is necessary to anchor the boat before diving is done.

Armored diving requires the use of a diving suit, or scaphander, which is composed of a one-piece rubberized cotton-cloth suit, copper headgear or helmet, copper corselet to which

the helmet is screwed, leaden-soled boots, and chest and back weights. With these accessories a diver is enabled to remain under water for a longer period and to dive in weather that would prohibit naked diving and to go to deeper waters and to work in a systematic manner. As soon as dressed the diver is helped to his position on a ladder hanging over the side of the boat. The necessary attachments are put in place; the air pipe, the life line or tender line, and the helmet are attached; the air pump is started, the face glass screwed tightly, and the air release valves opened. When everything is ready, the diver descends and then lets go his hold plunging backwards into the water and sinking quickly to the quiet depths below. He carries a hoopnet capable of holding fifteen pairs of ordinary-sized gold-lip shells. In his first dive the diver remains under water for but a short time, say, from ten to twenty minutes. This is necessary for his readjustment to the condition below. As soon as he is ready to ascend he signals to the tender who pulls him up slowly. The diver does not come out of the water immediately, but remains about five meters below the surface for about two-thirds the length of his working time on the bottom. This is an important precaution in order to avoid a sudden change in pressure; that is, to permit the pressure of the air to be released from the blood gradually.

The physical as well as the physiological condition of the diver determines, therefore, how long he can work on the bottom and how many times he can go down in a day. Generally, the dive lasts from fifteen to twenty-five minutes, and rarely exceeds thirty minutes; five dives a day are considered a fair average.

Armored diving is very strenuous as well as dangerous, and only those of robust constitution can continue in this occupation without impairing their health. Records show that there are more casualties resulting from constitutional injuries than from the attacks of sharks or other fishes or from the fouling of the air hose.

In the pearl-shell fisheries in the Philippines there are many experienced licensed armored divers, among whom are Moros, Christian Filipinos, and Japanese. The Japanese are recognized masters in armored diving, but the Filipinos are apt pupils, and there are several that can equal if not excel the best of the Nipponese divers.

Pearl-shell fishing in the Philippines is going on the year round, both for the pearls and for the hard shells, which are in

great demand in the manufacture of buttons and use in other crafts. The Sulu pearls are noted for their excellent quality and have been known in the markets of the world for four hundred years. It has been claimed that the pearl industry in Sulu has been on the decline because of the decrease in price of shells; but the fisheries have continued to yield an ample number of good pearls. And it may be considered that the collection of pearl shells is only incidental to the real objective of every boat owner, since the income from the mother-of-pearl alone cannot defray all the expenses for operation and repair of the boats.

AMOUNT AND VALUE OF SHELLS

The total amount of unmanufactured gold-lip shells exported from the Philippines to the United States, Great Britain, Germany, Spain, British East Indies, Hongkong, and Japan in 1927 was 247,412 kilograms valued at 191,491 pesos and in 1928 was 214,782 kilograms valued at 166,158 pesos.

The port of Jolo exported over 100,000 kilograms of unmanufactured gold-lip shells valued at 108,917 pesos to Sandakan and Singapore in 1929; and during the first nine months of 1930 the shells exported to the same countries totaled 20,013 kilograms valued at 17,776.60 pesos.

The export from the port of Zamboanga to Singapore and London amounted to 11,727 kilograms, valued at 10,821 pesos, in 1928; 3,951 kilograms, valued at 3,215 pesos, in 1929; and 12,312 kilograms, valued at 13,667.35 pesos, during the first six months of 1930.

During the present year (1930) the price of the gold lip fluctuated between 38 and 45 pesos per picul² at the fishing centers and reached as high as 53 pesos per picul in Manila. On the whole, these prices are considerably below those of fifteen years ago. It is feared that the local trade in pearl shells will not recover its former status in the face of stiff competition from Borneo and other southern foreign ports. The button factories in Manila receive regular consignments from Sandakan, Kudat, and Singapore.

The major part of the pearl shell obtained in southern waters enters the custom houses in Jolo, Zamboanga, and Davao, and is exported to London and Paris via Singapore, or to Sandakan for the Oriental markets; only a small percentage of the crop gathered from these grounds reaches Manila directly from the

² One picul (or pico) = 63.25 kilograms = 139.44 pounds.

three southern ports. The two button factories in Manila; namely, the Philippine Button Corporation on Misericordia Street and the Manila Button Factory at Pandacan, receive raw materials from Polillo, Aparri, Bantayan, Cebu, Bohol, Cuyo, and Palawan, and in addition get consignments from Singapore, which is a rather significant fact. Singapore is the big market for shells collected from the adjacent regions, and the fact that shells are much cheaper there than in the Philippines enables that port to trade with Manila. This competition is partly responsible for the general low prices of pearl shells in the local markets.

UTILIZATION

The gold lip is utilized primarily in the manufacture of buttons, but it is also used in a great variety of practical and artistic articles. From this shell are manufactured such novelties as fish and salad plates, nut dishes, salt dishes, olive and pickle forks, and ice-cream spoons and dishes. Handles for knives, hand mirrors, opera glasses, umbrellas, canes, and similar objects are made from the finest grades of mother-of-pearl. It is highly adapted to the making of belt buckles, shoe buckles, bar pins, beads, studs, cuff links, and hat pins, and to the ornamentation of fancy work or inlays of furniture, clocks, inkwells, picture frames, cigarette and vanity cases, pencils, and fountain pens. The meat is prepared as food.

BLACK-LIP PEARL SHELL (PLATE 2)

Common name: Black lip.

Local names: *Concha negra* (Sp.); *tipay batu* (Tausug); *tipay tipay* (Vis.).

Trade names: Black lip, Bombay, Tahiti, Gambia, Auckland, Panama, Hikueru, Banda.

Scientific name: *Pinctada margaritifera* (Linnæus)=*Avicula margaritifera* Lamarck=*Margaritifera margaritifera* Linnæus=*Meleagrina margaritifera* (Linnæus)=*Pteria margaritifera* (Linnæus).

Description.—Shell orbicular, generally somewhat more convex than *Pinctada maxima* (Jameson), smaller, and the hinge margin shorter. Exterior greenish or dark brown marked with radial rows of white spots running from the umbo to the margin. Nacre highly iridescent, somewhat steely in luster, with a dark smoky marginal band.

The shell figured has the following measurements: Height, 12 centimeters; breadth, 12; diameter, 2.6; length of hinge, 6.5.

DISTRIBUTION AND OCCURRENCE

The black-lip pearl oyster is more widely distributed than its larger congener, the gold lip. In the Philippine Archipelago it is common in waters from 2 to 30 meters in depth along the shores of almost all the islands. The most important grounds are in the Sulu group, Cuyo Islands, Bohol, Tañon Strait, Cebu, Bantayan; on the northern coast of Negros and the southern and eastern shores of Guimaras Island; off Balasan, and New Washington in Capiz; around Masbate, Leyte, Samar, Sibuyan, and Mindoro; in some bays along the coast of Zambales and in Lingayen Gulf; along the shores of Cagayan, Tayabas, the Bicol Peninsula, and the Batan Islands.

This species, like its close relative, occurs in warm, temperate and tropical seas. It thrives well in bottoms of coarse sand with dead coral or rock and plant growth to which the young may attach. It is a notable fact that pearl oysters cannot grow on living coral. They rarely survive in sandy places where the currents make sand burial a common occurrence.

LIFE HISTORY AND HABITS

The life history of this species is essentially similar to that of the gold lip. The course of its natural life follows the usual stages that a unisexual bivalve undergoes. The female produces numerous eggs, which are fertilized by chance in the water by the sexual products of the male. The larvæ resulting from the union are by nature and structure planktonic; that is, buoyant and floating on the surface. As such their life in the open sea is exceedingly precarious as they are at the mercy of the elements, which may carry them away from their parental surroundings. At the end of from thirty to forty-eight hours, after passing through the trochophore and veliger stages they become shelled larvæ; and at the end of the third day their roving adventure ceases as they sink and attach themselves to hard objects they chance to fall upon. They are now known as spat. Their attachment is made possible by the aid of the sticky threads of the byssus. The ropelike "roots," however, may wear off any time but new growths almost immediately appear, for it is essential that the growing mollusks adhere to some resisting collector. It has been asserted that pearl oysters torn from their original attachment and deprived for a considerable period of any collector for the byssus to adhere to perish soon. In their natural environment, these mollusks lie with the right, or less convex, valve beneath and with the

posterior edge of the shell elevated at an angle of about 20 degrees.

The growth of the black lip is comparatively rapid in Philippine waters, since there are no abrupt changes in the surroundings to retard or suspend its development. It does not "rest" as the shells generally do in temperate or cold regions. The size and age at which this species is sexually mature are as yet not definitely ascertained; there is, however, a fair indication that it starts to spawn at a small size and at the age of a little over a year. Female specimens of about 9 centimeters in length were found to contain ripe ova, and male individuals 15 centimeters in length were also found sexually ripe. It has been observed that at about two years of age it attains the present legal size of 9 centimeters, nacre measurement taken at right angles to the hinge joint; or about 11 centimeters, maximum outside long-axis measurement taken at right angles to the base. Undoubtedly the black lip continues to grow, as large shells 14 centimeters and over in external measurement are now and then found. These overgrown individual shells, however, are useless or of little value because they are invariably dead, covered with coral or sponge growths, and well perforated by boring mollusks or worms. In oysters of legal size and above, pearls are usually produced, but these are black and almost always of dead luster and have, therefore, very little commercial value, so that fishing for the black lip is done primarily for its mother-of-pearl alone.

At no place in the Philippines is artificial cultivation of this species carried on. There are favorable localities in the Visayas and in Sulu where pearl-oyster farming may be profitably conducted, but work of this nature may not go beyond the experimental stage for some time as there are serious difficulties connected with it.

As this species is more abundant in shallow waters, the use of "machine diving" is practically dispensed with. In the southern region the divers have three other ways of gathering the pearl shells; namely, by actual diving, by dredging, and by a three-pronged catcher drawn by a rattan rope. The last method can be used only in quiet clear water, since it is only effective when the fisherman in the boat can see the shells at the bottom. On the whole, skin or naked diving is generally preferred. The divers go down at random and search for shells after reaching the bottom. This method still persists although it is uncertain

and wasteful in both time and energy. Quite recently, however, a labor-saving device, the water glass, was introduced. The glass, which may be in the form of a pail or flower pot with glass bottom, is used to aid the diver in scanning the grounds. With this it is possible for him to locate in clear water the shells on the sea floor 30 to 50 meters in depth. It is now widely used by the Moros and other divers in the Philippines. Also, the so-called fishermen's goggles have become popular with them.

The Moros are the most expert naked pearl divers in the Philippines. They are exceptionally hardy, skillful, and daring sailors and fishermen for whom the sea has an intense fascination. The tales of their exploits and adventures in the treasure realm of the deep are accounts of romantic as well as economic significance.

When a Moro skin diver is ready to plunge he fills his lungs several times and then expels the air slowly. Then he takes a deep breath and sinks a few feet below the surface, quickly dives to the bottom, where he collects as many shells as possible. As soon as he reaches the limit of his staying power, he straightens himself, and pushing with his feet on the bottom springs upward, shooting to the surface with startling speed. He delivers his catch to his companion in the vinta and rests for a moment before repeating the performance. Generally when diving in deeper water, a naked diver goes down with the aid of a heavy stone attached to a rope.

Each diver may carry a bagnet in which he places his catch; or a sort of basket woven from fish nets is lowered to the bottom to be used by the members of one outfit, which generally consists of an outrigger dugout, or vinta, and two to five divers with their families.

Few, if any, Moro naked divers venture in water deeper than 35 meters. It is probable that there are Moro skin divers who can go deeper, but it is certain that their working time is very limited indeed. Twenty meters may be considered good diving, and in many of the grounds in Sulu worked by naked divers the depth of the water is even less than 10 meters. The number of those that can remain under water longer than two and a half minutes is very small, and it is doubtful whether there is any Moro naked diver who can stay under for three minutes, reports and claims to the contrary notwithstanding.

In the Sulu Archipelago hundreds of vintas may be seen along

the shallow waters between small islands busily engaged in naked pearl-shell diving. Men, women, and boys all join in the occupation. The women on board open the shells, take the meat out and dry it in the sun. The shells are cleaned and placed in the hold of the boat. The Moro naked divers work for themselves; few, if any, work under contract.

AMOUNT AND VALUE OF BLACK-LIP SHELLS EXPORTED

The total amount of shells obtained annually from the Philippine pearl-shell banks, while not accurately known, is calculated to be not less than 20,000 kilograms valued at about 6,000 pesos. During 1928, the port of Jolo exported 2,205 kilograms of unworked shells valued at 355 pesos to Sandakan and Singapore; during 1929, 4,328 kilograms valued at 1,100 pesos; and during the first six months of 1930, 257 kilograms valued at 80 pesos. Cebu exported in 1928 to London 63 cases of "common shells" valued at 2,500 pesos. The classification used in the invoice is very indefinite, but there is no doubt that a few black-lip shells went with that consignment. Zamboanga exported 12,477 kilograms of M. O. P.³ shells valued at 11,821 pesos to London and Singapore during 1928; 4,951 kilograms of M. O. P. shells valued at 3,210 pesos to Singapore and London during 1929; and 12,312 kilograms of M. O. P. shells valued at 13,667 pesos to London during the first five months of 1930. The exact amount and value of the black lip included in these exports are not known. Legaspi, Iloilo, and Davao reported no exportation of black-lip shells during 1928, 1929, and up to the first six months of 1930. The two button factories in Manila receive shipments of black-lip shells from the Visayas, Zambales, Pangasinan, Cagayan, and Tayabas, which run into several thousand kilograms. The price of black lip in Sulu and in other places in general is around 18 pesos per picul; in Manila it is a trifle over 20 pesos per picul.

UTILIZATION

The black-lip shells are used in the manufacture of common and fancy buttons for overcoats and cloaks, of inlaid works, of cameos, and of jewelry and miscellaneous objects. The meat is utilized extensively as food, either boiled or dried. In the Sulu Archipelago, the pearling crews derive a considerable income from the dried flesh of the pearl oyster, which they sell to the Chinese who use it in preparing nutritious soups and dishes.

³ M. O. P. means mother-of-pearl. M. O. P. shells consist of a combination of gold-lip and black-lip pearl shells.

TOP SHELLS

Common names: Top shell, conic shell, loch, trochus.

Local names: Trocas (Sp.); simong or samong (Vis.); lak (Tausug); Susong dalaga (Tag.); chin leh (Chinese).

Trade names: Trochus, top shell, trocas, trochas.

SPECIES COMMERCIALY USED

Smooth variety *Trochus niloticus* Linnæus

Trochus maximus Koch

Rough varieties *Trochus obeliscus* Gmelin

Trochus noduliferus Lamarck

The great majority of the shells used are the smooth variety, *T. niloticus* Linnæus. The rough varieties, *T. maximus* Koch and *T. obeliscus* Gmelin together would probably not constitute 20 per cent of the total consumption. *Trochus obeliscus* is generally referred to in trade as the "female." The other rough variety, *T. noduliferus* Lamarck, is seldom met with.

TROCHUS NILOTICUS LINNÆUS

Shell conical, thick, subperforate, covered by a corneous, striate, brown or yellowish cuticle lost on the upper whorls; color beneath the cuticle silvery white, longitudinally, somewhat obliquely, striped with crimson or reddish brown, base spotted with radiating lighter shade of the same color. Spire strongly conical, apex acute, whorls 8 to 10, generally 9, first two smooth or eroded, following four spirally beaded and tuberculate at the sutures, remaining whorls smooth and flat on their outer surface, separated by linear sutures, the body whorl expanded, dilated and compressed at the obtuse periphery, more or less convex below, indented at the axis. Columella oblique, terminating in a denticle below and with a strong fold above, deeply inserted in the axis. Umbilical tract covered by a spiral deeply entering callus. Aperture transverse, very oblique. Height, 75 to 100 millimeters; diameter, 80 to 120.

TROCHUS MAXIMUS KOCH

Shell very similar to *Trochus niloticus* Linnæus, only somewhat less ponderous but more strictly conical. Whorls decidedly plicate or tuberculate, body whorl not dilated at the periphery, more or less flat at the base. Columella less oblique.

TROCHUS OBELISCUS GMELIN

Shell solid, imperforate, thick, spire more or less acute above. Color greenish more or less mottled with brown, base white, inside pearly. Whorls 12, occasionally 13 or 14, upper ones

slightly exerted and plicate, tuberculate or undulating at the sutures, encircled with one or two spiral series of small tubercles, which are increased to five or seven on the lower whorls; angulate at the periphery. Base flat, with shallow concentric grooves. Aperture oblique, outer wall grooved within, basal margin straight, deeply notched at its junction with the columella. Columella with strong acutely carinated spiral fold. Height, 75 millimeters; diameter, 75.

TROCHUS NODULIFERUS LAMARCK

Shell solid, imperforate, conic pyramid. Color whitish pink, more or less mottled with rose (old specimens grayish). Whorls 10 to 12, prominently knobbed around the sutures and periphery, the tubercles from fourteen to sixteen on the last whorl. Base flat, polished, with shallow concentric grooves, white or tinged with green around the central portion. Aperture smooth within. Columella fold strong, heavy, directed downward. Height, 70 millimeters; diameter, 75.

OCCURRENCE AND DISTRIBUTION

The top shells are widely distributed throughout the Philippines, appearing abundantly in many of the islands. They are usually found near the outer edge of coral reefs where they occur more or less singly; and while a few may be met with under a large stone they never are in great numbers over a given limited area.

These shells may be secured in quantities in the shallows around Sitanki and Tawitawi; in Davao Gulf; along the east coast of Mindanao and the north and west coasts of Palawan; around Cuyo, Bantayan, and Cebu; along the east coast of Bohol and the north and west coasts of Negros; around Lingayen Gulf and along the coasts of Tayabas, Camarines Norte, and Camarines Sur. The north coasts of Mindoro and Lubang Island, east coast of Masbate, north and west coasts of Samar, and the rocky shoals of Leyte and Sibuyan also yield considerable numbers. In general, all the coral reefs and shallow rocky bottoms around the small islands of the Archipelago are natural sources of top shells. The mollusks are collected by wading along the reefs or by skin diving in water from 2 to 15 meters deep.

LIFE-HISTORY AND HABITS

In the Philippines, the facts regarding the breeding season of the top shells and the size at which they start to spawn are not

definitely ascertained. According to Seale⁴ the great top shell (*Trochus niloticus*) reaches maturity in three years. It is well known that the sexes of top shells are separate; that is, the individual is either male or female. The reproduction is always by eggs, which are laid on rocks or glued to seaweeds in masses. The meeting of the eggs and spermatozoa takes place in the water and is left entirely to chance. From the fertilized egg is developed the trochophore in which the nearly spherical embryo grows a circlet of bristles or cilia. This circle of hairs separates the portion bearing the mouth and anus from the rest of the body. The trochophore is transformed into the veliger, in which the cilia become elongated and are pushed to the front of the embryo while the part of the body from which the bristles arise becomes elevated and develops on each side a more or less distinct lobe, the velum. In this stage the shell gland and visceral sac appear on the upper part and the foot is seen on the lower. The veliger swims about in the sea, until the increasing weight of its shells forces it to settle to the bottom. The young gastropod is capable of moving about for a considerable distance. It crawls by means of its powerful foot along the edges and bottoms of rocks in search of food, which consists of sea algæ and various organic substances. It is primarily vegetarian, subsisting upon dead or decaying vegetable matter.

AMOUNT AND VALUE OF SHELLS

There is no way of determining accurately the total annual amount of trochus fished in Philippine waters. However, a close estimate of the yearly quantity of collected shells that are disposed of commercially, either as unworked material for export or for domestic use, may be derived from the records at the ports of entry and from the reports of the Insular Collector of Customs.

The Philippine exports of trochus shells to China, British East Indies, and Japan amounted to 113,626 kilograms valued at 8,715 pesos in 1927, and 81,514 kilograms valued at 11,064 pesos in 1928. The port of Jolo exported to Sandakan and Singapore 1,587 kilograms of top shells valued at 1,032.70 pesos in 1929, but none during the first half of 1930. A fair amount is occasionally shipped from Jolo to the two button factories in Manila. Shells entered at Jolo are obtained from the Sulu beds and along the southern coast of Palawan.

⁴ Philip. Journ. Sci. § D 11 (1916) 263.

During 1930 trochus shells were sold from 40 to 48 pesos per picul in Jolo and Zamboanga, and in Manila the price reached as high as 52 pesos per picul.

UTILIZATION

Trochus shells are used chiefly in the manufacture of buttons. The meat is also utilized for food, and a considerable number of shells become cheap or unusable for industrial purposes as a result of the common practice among native fishermen of boiling or burning the shells in order to extract the meat. The heat destroys the luster of the shells, consequently their value in button making is greatly reduced. The shells should be buried in the sand for at least a month and then washed in sea water. The natural sheen of the shells is never impaired by this process. This is by far the most practical method of preparing the top shells for industrial purposes. Besides buttons, many beautiful objects for home and office, bric-a-brac, jewelry, and small ornaments are made from the pearly shells of trochus.

TURBAN SHELLS (PLATE 8)

Common names: Green snail, sea snail, turbo.

Local names: *Lalong* (Tag.); *bolalo* (Vis.); *lagong*, *laong* (Tausug); *tua leh* (Chinese).

Trade names: Green snail, turban shell, turbo.

Scientific name: *Turbo marmoratus* Linnæus.

DESCRIPTION

Shell large, turbinate, solid, imperforate, ventricose, green, marbled with white and reddish brown. Whorls 6 to 7, smooth or concentrically striated, the first two yellow or yellowish white, the last very large, flattened or concave above, bearing two nodose keels below and a nodose carina above. Aperture large, interior pearly, columella arched, bearing a transverse fold more or less ear-shaped. Operculum white, subcircular, thick, somewhat concave within. Height, 150 millimeters; diameter, 155.

OCCURRENCE AND DISTRIBUTION

Closely associated with the top shells, the green snail is found throughout the Philippine Archipelago; the distribution is so widespread that there is hardly a rocky islet or coast that does not harbor this mollusk. It occurs in greatest abundance along the edges of coral reefs and in water several meters deep. A number of turban shells may be encountered under large boulders along rocky shores.

Fairly extensive turbo fisheries exist in certain localities in the Sulu Archipelago. Sitanki and Tawitawi and the adjacent islands near Siasi yield considerable quantities of green snails. The north and west coasts of Palawan are natural grounds. The Batan, Cuyo, and Bantayan groups are exceptionally rich in turbos. The coral reefs and shoals along the north and west coasts of Negros have contributed to the shipment from Cebu. The Visayan islands on the whole may be regarded as productive grounds for this species. From the coasts of Pangasinan, Cagayan, Tayabas, Camarines Norte, and Camarines Sur large numbers of turban shells are secured and sent to Manila.

LIFE-HISTORY AND HABITS

Like the top shells, the green snail is unisexual; that is, the individual is distinctly male or female. In these two species the stages of development from the fertilized egg to the veliger are essentially similar. The resulting small snail is an active bottom dwell, capable of moving for a considerable distance along the edges of rocks by means of its flat foot in quest of food. It is primarily a vegetable feeder, subsisting mainly upon sea moss or algæ.

The animal is sexually mature at the age of 3 years when it reaches a diameter of from 80 to 90 millimeters. Apparently it grows slowly. The breeding season and the rate of growth of this species are not fully known.

AMOUNT AND VALUE

During the year 1927, the Philippine export of unmanufactured green snails to the United States, British East Indies, and Japan amounted to 4,037 kilograms valued at 2,230 pesos; during the year 1928, the total exportation was 11,666 kilograms valued at 2,423 pesos. While the amount of exported shells was practically trebled in 1928 the average price per kilogram was reduced to almost one-half.

The port of Zamboanga exported to Singapore 716 kilograms valued at 310 pesos, during 1928; 375 kilograms valued at 226 pesos, during 1929; and none during the first six months of 1930. From the port of Jolo there were exported to Sandakan and Singapore 2,598 kilograms valued at 1,287 pesos in 1928, and 3,408 kilograms valued at 1,740 pesos in 1929, but none from January 1 to June 30, 1930. Legaspi and Iloilo had no exportation of button shells during the years 1928, 1929, and

the first half of 1930. Since its opening in 1926 to July, 1930, the port of Davao had only one exportation of button shells, and that was on May 12, 1930, when 127.5 kilograms were shipped to Yap in the South Sea Islands. In 1928, the port of Cebu exported to London 63 cases of common shells valued at 2,500 pesos, but none during 1929 and the first seven months of 1930.

Generally these shells are taken from the fisheries near the respective ports of entry. Green snails obtained in the waters of southern Mindanao and of the Sulu Archipelago are entered either at Jolo or Zamboanga whence they are reshipped to Sandakan, Singapore, China, Japan, or Manila. Cebu is the port of entry for button shells originating from Bantayan, Bohol, and other neighboring places. Shells from Mindoro, Pangasinan, Aparri, and Tayabas are brought to Manila where they are utilized locally.

The price of the shells is primarily dependent upon the market fluctuations and varies with the quality and assortment. At present (1930) shells of good quality and without defects bring from 30 to 55 centavos per kilogram in Manila.

UTILIZATION

In Scandinavia the green snails for centuries were utilized as royal drinking cups. The shells were fashioned, polished, silver-mounted, and set with precious jewels. They are, however, no longer used as such nowadays, but many of them may be seen in cabinets kept there for sentimental reasons.

The principal use of green snails is for button making. But the thick pearly shell of this species has also found use in the manufacture of an infinite variety of articles such as spoons, forks, buckles for belts and shoes, handles for toilet objects, knives, opera glasses, and various instruments, inlays or decorations on fountain pens, desks, ink wells, clocks, picture frames, vanity cases, napkin rings, lamp shades, and many beautiful bric-a-brac. The Japanese and Chinese prepare the soft parts into tasty dishes. The Filipino fishermen utilize the meat extensively as food, and as a result, many shells that are otherwise valuable are rendered useless or cheap by the common practice of applying heat to extract the animal from the shell. Boiling or burning the hard substance injures the pearly luster. However, it is claimed that pouring boiling water on the shells does not destroy the luster and facilitates the removal of the animal, which can be easily pried out as it usually comes out of the shell upon being scalded. The shells can be satis-

factorily cleaned for industrial purposes by burying them in the ground for at least a month and then washing them in sea water.

WINDOW SHELL

Common names: Window shell, Chinese window shell, window oyster.

Local names: *Kapis* (Tag.), *lampirong* (Vis.), *kalampinay* (Bicol).

Scientific name: *Placuna placenta* Linnæus.

DESCRIPTION

Shell white, orbicular, rarely suborbicular, thin, pellucid, resembling somewhat a circular sheet of thin mica, foliaceous, valves compressed, flattened, margins rarely, if at all, subflexuous, marked with longitudinal striæ crossing concentric wavy lines, more or less wrinkled, representing stages of growth. Outside dull finish, inside silvery. Right valve flat, teeth unequal in length, diverging like the letter V. Left valve concave, with two divergent grooves corresponding to the teeth on the right valve, rayed with purple near the umbo.

Average of the short diameter of the large shells measured along the line bisecting the angle formed by the teeth, 12 to 14 centimeters; average thickness at the center of the flat valve, 1-1.5 millimeters.

DISTRIBUTION

The window shell occurs in certain definite localities in the Philippine Archipelago. Natural beds are found on the tide-flats at Parañaque, Binakayan, Kawit, and Samal, where the fisheries are extensive and rich, supporting an industry of considerable importance. The grounds in Bacoor Bay, doubtless the most productive, yield large crops regularly, while the Samal fisheries in Bataan, although potentially rich are too uncertain and occasional on account of the excessive sedimentation and freshening of the water during June, July, and August particularly, when the rainfall is at the maximum, affecting materially the seasonal produce. Productive placuna beds exist at Sual in Pangasinan; at Panglao and Talibon in Bohol; at Valladolid and Cadiz Viejo in Occidental Negros; on the eastern shores of Guimaras; at Oton and Leganes in Iloilo; on the northern coast of Capiz and on the eastern side of Masbate; at Matican and Lampinigan Island, near Isabela, Basilan; at Dungun in a little bay east of Buan Island, on the south side of Tawitawi group, Sulu.

HABITAT, HABITS, AND CULTIVATION

Although usually found in the littoral zone, window shells are known to live in water as deep as 40 meters. They appear to thrive only on mud or sand-mud bottoms in shallow salt-water bays or at entrances of estuaries, and they seem to be able to survive where there is a considerable flow of fresh water. Like the common edible oysters, they subsist mainly upon microscopic marine organisms, particularly diatoms. Except during the early stage when the larvæ float and drift with the current these bivalves do not move about but are nevertheless free and unattached, lying on the bottom on their convex, left side. They are not of the actively burrowing kind. Their foot is not used for locomotion nor for digging but it functions as an instrument to prevent the mud getting into the gills and other organs. The window-shell oysters, like all the other bivalves, breathe and feed simultaneously, their right valve being raised slightly above the level of the left valve when performing the double function.

In some mollusks both reproductive elements are produced by the same individual; but, in most, an individual is either male or female. The sex of a shell is not betrayed by any superficial characters and can only be determined by microscopical examination. In the window shell the sexes are separate; the eggs and sperm are cast into the water at spawning time and their meeting is entirely left to chance. The mature ova resemble the adult shell in form; the spermatozoa have rounded heads and exceedingly long delicate tails. The shellfish is extremely prolific, each mature female producing several thousand eggs. It is a periodic spawner. In Bacoar Bay it spawns in April and has been found to reach a short diameter of from 55 to 77 millimeters at the end of the first year, and of about 133 millimeters in two years. Its rate of growth is apparently fairly fast in the waters of Manila Bay. It matures in three years.

The natural supply of window shells in shallow waters is sufficiently large, and there is little likelihood of their ever becoming extinct and it would be impossible to deplete them as their habits and methods of propagation are such that the spat would in a very short time repopulate a fishery if it could be exhausted. In most of the fisheries around Manila Bay the fishermen find it unnecessary to dive for the shells since these can be secured by simply wading in shallow water during low tide and feeling about with the toes and fingers. At Samal,

however, divers equipped with a diving headgear collect shells in water from 5 to 10 meters deep. Eighty per cent of the shells gathered by divers in this locality are dead. These are usually found buried in the muddy bottom. The natural though catastrophic occurrence, namely, mud burial, is responsible for the sporadic yield of the beds in close proximity to streams and lowlands.

There are no laws specifically regulating the collection of these shells, as regards size and season; but it is believed that such legislation would be unnecessary since the fishermen realize that only large shells are of the greatest value and do not as a rule fish out small ones for the market. Fishing for "seeds" or undersized shells is done practically throughout the year but only for the purpose of transferring them to the private claims where they are left to grow until they attain marketable size. This is a common practice among the fishermen in Bacoar Bay in particular, and it is mainly by means of this transplantation method that the fishery has been successfully maintained since it conserves the stock by allowing large numbers to spawn at least once before they are harvested.

In Binakayan and Kawit a sort of artificial cultivation is carried on with considerable success. Along the shore line may be seen staked-off private claims the respective owners of which employ men to guard the property against poachers. These claims constitute the main source of the industry in the region, although in the deeper water there is a considerably large area of public ground from which shells of all sizes may be obtained. Small and half-grown shells are planted on the mud-flats that are not exposed at low tide. The relaid shells are allowed to grow until they become marketable; these are usually harvested a year after the planting, but when the demand is great or the owner is in need of cash the farms are fished out earlier, as early as five or six months after the transplantation. It is interesting to note that window-shell culture and oyster farming are so successfully carried on simultaneously in Binakayan and Kawit that pretty nearly all the oyster farms here are also devoted to the raising of window shells. It has been reported that a good oyster-window-shell farm yields as much as twice the revenue if the ground is planted only to oysters. This is a suggestion of practical importance to all rational oyster culturists. So far as known no such combination of farming is conducted in any other district outside of Bacoar Bay.

A large number of the residents of Kawit and Binakayan engage in window-shell fishing, gathering no less than 20,000 per week, during favorable weather. They collect large and small shells, but the small ones are transferred to private plots of from 100 to 200 square meters, in which they are allowed to grow for five to eight months; they are then marketable. The large shells are brought ashore in dugouts and carried in bamboo baskets to the cleaning premises.

The shells are first soaked in basins of fresh water to loosen the scales on the outer surface; the scales are then scraped off with a flat piece of metal, and the edges are smoothed by rubbing them against a rock or earthen jar. The shells are graded according to quality and size and placed in large bamboo baskets (batulan or canastro) each containing one laksa (10,000) valves. Women constitute the majority of the workers, and it is not very difficult for a woman to clean 2,000 shells in a day for which she generally receives from 1 to 1.50 pesos. The wages, of course, fluctuate according to the market price of the cleaned products.

THE INDUSTRY AND ITS POSSIBILITIES

The industry has been almost entirely under the control of Chinese. The native fishermen, with few exceptions, are contracted to deliver the cleaned products to Chinese dealers who usually advance money to be paid in shells at the price when the money was obtained. It is obvious that the Chinese have the upper hand in the transaction. This is a situation that is very difficult to remedy since the native fishermen do not have any way of disposing of their product in great quantities except through the foreign dealers. The lumber companies or construction firms, many of which are owned by Chinese, send out agents to deal with the natives who perforce accept the dictated quotations. Not until the Filipino fishermen learn to form a coöperative organization will they be able to demand reasonable prices for their products.

Quite recently, however, at the inception of shell shops here, managed by Americans, the native fishermen have been selling their raw products directly to the firms or through agents sent by them to the fishing centers to deal with the native gatherers.

Manila alone uses every year several million window shells in house construction and shell crafts. The demand is increasing; and as soon as the utility of this material is recognized abroad, especially in southern California and in other semi-

tropical or tropical countries where the most popular types of homes are the bungalows in which the window shell can be used with artistic effect, it is expected that the export trade will be greatly increased.

In 1927, the total export of unmanufactured window shells from the Philippines to the United States and Hongkong amounted to 552 kilograms valued at 40 pesos, and in 1928 the exportation totaled 612 kilograms valued at 320 pesos. The export for 1929, although not yet officially reported, is claimed to have increased three fold in quantity. Manufactured articles, such as lamp shades and other shell-crafts, exported to the United States, Great Britain, Belgium, Germany, China, British East Indies, Dutch East Indies and Hongkong were valued at 54,157 and 69,219 pesos for 1927 and 1928 respectively.

In trade the right valves are known as flat, the left valves as bent, and shells that square above 80 millimeters are classified as "head." The so-called "first flat" and "first bent" or simply "firsts" are shells that square from 75 to 80 millimeters; the "seconds" square from 70 to 75 millimeters; the "thirds" from 60 to 70 millimeters; and shells that square less than 60 millimeters are graded as "fourths."

In Manila the price of window shells varies from 3 to 20 pesos per thousand, depending upon the grade and upon supply and demand. Sometimes these shells bring as much as 30 pesos per thousand. In Binakayan, Kawit, and Samal uncleaned and cleaned shells are sold for from 2 to 12 pesos per thousand.

UTILIZATION

The Chinese have long utilized this shell instead of glass for window panes. In the Philippines, it has been used for this purpose for hundreds of years. The windows in some of the oldest churches in Manila, such as the St. Augustine, Recollect, Franciscan, and Jesuit churches, and in many of the old convents and churches in the provinces, are proof of the strength and durability of the shell. There is no question as to its beautiful effect, and its usefulness can easily be recognized in the various articles that are manufactured from it. Art and science find it remarkably adaptable for making shell-craft products, such as, paneling, concealed lighting systems, partitions, shades, lanterns, shields, screens, trays, place cards, picture frames, coasters, candle sticks, cake and fruit dishes, and innumerable other novelties for home and office. These articles are all hand made, plain and hand painted with beautiful designs and scenes.

Saddle oyster shells are also utilized in shell-craft but to a very limited extent. Two species enter into the supply of the raw material, namely, *Placuna papyracea* Lamarck and *Placuna sella* Lamarck. These shells are known in trade as *Rufo* shells. They have a natural tinted coloring and give a mellow translucent effect. Beautiful shades and shields are made from them.

CHAMBERED NAUTILUS

Common names: Chambered nautilus, pearly nautilus.

Local names: Lagang; layagan (Vis.).

Scientific name: *Nautilus pompilus* Linnæus.

DESCRIPTION

Shell discoidal, involute, smooth, imperforate, white, with wavy, rather broad, bands of reddish or yellowish brown at the posterior end. Umbilicus covered by a callous pearly deposit. Interior of shell divided into 30 to 35 chambers by concave partitions or septa, perforated in the middle by a small siphonic tube.

DISTRIBUTION

The chambered nautilus is a cuttle-fish of wide distribution in tropical seas. It occurs in large numbers in the Polynesian islands, particularly around the islands of New Hebrides and the Fiji group. In the Philippines it is chiefly abundant on the southern coast of Negros, in Tañon Strait, and around Bantayan and Cebu. It is also found in considerable quantity in Palawan, Cuyo, Basilan, Leyte, and Mindoro. Undoubtedly this species inhabits the rocky places around Lingayen Gulf and along the coast of Cagayan, Tayabas, Camarines Norte, Camarines Sur, and Mindanao. The most important grounds are on the southern coasts of Negros and at the north end of the channel between this island and Cebu.

LIFE-HISTORY AND HABITS

The pearly nautilus is a natural coral-bottom dweller, crawling on the rocky floor of the sea where it procures its food among its abyssal associates. It is carnivorous and subsists mainly upon crabs and lobsters, which it hunts among the coral rocks. When crawling on the bottom its natural position is with the head downwards and the shell, accordingly, uppermost; when floating it swims backwards, with the shell foremost; a portion of the top of the shell is exposed; the animal is under water. It moves with a succession of jerks, after the manner of all cephalopods, due to the expulsion of water

from the siphon tube. When alarmed or disturbed it executes a sort of quick darting movement as it shoots water through its siphon more or less violently.

The mantle secretes the pearly floor of the cavernous outer or body chamber and adds new growth to the shell at the edge. As the nautilus grows, its shell becomes discoidal in form due to the effect of the animal's natural position while crawling on the rocky sea bottom. Periodically, as growth continues, the body of the animal is drawn forward and the muscle of attachment lowers itself to a certain interval where a pearly concave cell wall or septum is constructed. The muscular ligament grows only in front and wears off behind and always moves forward, except during the period of formation of each partition. The frequency of septum construction and the rapidity of the process are not known. The septa gradually increase in size and number and eventually a series of air cells is built. Specimens of about 110 millimeters in diameter when cut in sagittal section have been found to contain thirty-three septa. Passing through the center of each of these is the siphuncle, a membranous extension of the body connecting the innermost cell with the spacious body chamber. The thin hoselike membrane is supported and protected by a short calcareous tubular prolongation at each hole, and by means of this siphonic tube air is conveyed to the chambers. Analysis shows that this air is richer in nitrogen than the atmosphere. It therefore increases the buoyancy of the chambers sufficiently to enable the nautilus to maintain the relative weight of its growing body and its shell in water.

The sexes of this species are separate. The male products are introduced into the mantle cavity of the female by one of the arms of the male. This arm is especially modified as an intromittent organ and is called the hectocotylus arm. Fertilization and subsequent early processes in the development of the young are carried on in the body of the mother. The resulting offspring are called "polyps" and resemble the parents in all particulars. Nothing precise is known as regards the age and size at which this species is sexually mature, nor the length of its normal life.

As previously pointed out, the most important fisheries are on the southern coast of Negros, in Tañon Strait, and around Bantayan Islands. It has been stated that great numbers of nautili are obtainable along the southern shores of Negros Island at depths of between 400 and 600 meters and that they are

captured in deep-sea bamboo traps known as *bobos*. That the nautilus can thrive in water about 650 meters deep, there is no question; but it is rather doubtful whether or not this mollusk can be collected in water between 400 and 600 meters in depth off the southern coasts of Negros. In the first place, these depths are beyond the coral zone; coral reefs, the natural habitat of the nautilus, are in water that is less than 75 meters. In the second place, the so-called deep-sea bobos are usually set in water of not more than 60 meters in depth.

At present there is no systematic nautilus fishing in Philippine waters. The taking of this mollusk is only incidental, although the way it is caught may be regarded as fairly efficient and can be used for commercial purposes. Attracted by the smell of the bait, the nautilus enters the traps that are primarily set to capture bottom fish and crustaceans in deep waters. The mollusk as a catch is, therefore, only a by-product of a kind of deep-sea fishing in the Philippines. A considerable number of empty shells may be gathered from the shallow places and beaches of rich fishing grounds.

The chambered nautilus occurs abundantly in the Visayas during the summer, and fishing is usually most brisk in the month of June. The mollusk is trapped by large bamboo cages (*bobos*). These are generally rectangular or heart-shaped and operate on the principle of a rat-trap. They may have an entrance above, on the side, or at the end. The aperture is a funnel of sharp-pointed slats directed inwards, so as to allow the entry of the animal but preclude its escape. For the removal of the catch there is provided a sort of trap door usually located on the side or in the bottom. Each trap is weighted with stones, baited with cooked or partially spoiled crab or crayfish, and provided with a warp or lift rope to the free end of which is attached a bamboo float or buoy to indicate the location of the apparatus. Bait, which is particularly "high," that is, strongly scented, has been found very effective in attracting the nautilus through its sense of smell, which is apparently keener than its sense of sight. The smelly potage is usually wrapped in coconut fiber like a small parcel and then placed in the trap. The baited contraption is lowered to the bottom and left there for a period of several hours before hauling it up. Daily hauls are usually the practice.

In other regions the modes of capturing this animal for the embers or for the pot are quite interesting. In the South Sea Islands where the mollusk occurs in great abundance, skin

diving and trapping are the most common methods. The islanders catch the animal with their native fish-falls or with spears and dipnets in waters from 4 to 7 meters in depth. The traps are baited with sea egg or sea urchin (*Echinus*). The Fijians use wicker-work traps not much different from the bobos in principle. The bait used is boiled crayfish. As soon as a nautilus is discovered clinging to some prominent ledge the fisherman gently lowers his trap near the animal. The gear is either watched closely until the quarry is entrapped or left there with a marker to be examined after a certain period. For removing the catch the Fijians use a sort of grapnel consisting of a small piece of branched wood with the branches sharpened. A perforated stone as sinker is attached to the tool. This is lowered and passed through the opening on top of the trap until the pointed branches reach the animal. By a skillful manipulation the fisherman hooks his victim and hoists it safely into his dugout.

UTILIZATION

The nautilus has economic uses. The animal is eaten as a soup meat, boiled, or roasted. If properly prepared, the dried flesh would make an agreeable viand. The shell is now being used extensively in the manufacture of ornamental objects. The mother-of-pearl luster of the inside surface is very attractive for decorative purposes or inlays. Lamp shades, vases, dippers, and spoons are made of the shells. These are also used in making cameos. The local demand for nautilus shells is increasing. Shell shops are being established in Manila, and manufactured articles from sea shells have an increasing local trade. Chinese in the Philippines buy the shells, accumulating them for export to China where they are manufactured into buttons. Export to the United States or Europe is very limited.

ILLUSTRATIONS

PLATE 1

Philippine gold-lip pearl shell, *Pinctada maxima* (Jameson).

PLATE 2

Philippine black-lip pearl shell, *Pinctada margaritifera* (Linnæus).

PLATE 3

FIG. 1. Blanks marked off by tubular saw on shell of black-lip, *Pinctada margaritifera* (Linnæus).

2. Blanks marked off by tubular saw on shell of gold-lip, *Pinctada maxima* (Jameson).

PLATE 4

FIG. 1. Blanks cut from shell of gold-lip, *Pinctada maxima* (Jameson).

2. Blanks and finished buttons from shell of gold-lip, *Pinctada maxima* (Jameson).

PLATE 5

FIG. 1. Trocha shell, *Trochus niloticus* Linnæus var. *maximus* Koch.

2. Trocha shell, *Trochus niloticus* Linnæus.

PLATE 6

FIG. 1. Trocha shell, *Trochus noduliferus* Lamarck.

2. Trocha shell, *Trochus obeliscus* Gmelin.

PLATE 7

FIG. 1. Trocha shell, *Trochus niloticus* Linnæus; showing cuts for buttons.

2. Trocha shell, *Trochus niloticus* Linnæus; showing characteristic markings.

PLATE 8

Green snail, or turban shell, *Turbo marmoratus* Linnæus.

PLATE 9

FIG. 1. Green-snail powder boxes and hair-pin cup. (Courtesy of Philippine Shell-Craft Corporation.)

2. Green-snail buckles. (Courtesy of Philippine Shell-Craft Corporation.)

3. Green-snail table, or reading, lamp. (Courtesy of Philippine Shell-Craft Corporation.)

4. Green-snail desk lamp with narra base. (Courtesy of Philippine Shell-Craft Corporation.)

PLATE 10

Kapis, or window shell, *Placuna* (*Placenta*) *placenta* Linnæus; showing four commercial grades.

PLATE 11

- FIG. 1. Shell windows in the Episcopal Cathedral, Ermita, Manila.
2. Shell windows in the Philippine General Hospital, Manila.

PLATE 12

Screen made of window shell and red narra.

PLATE 13

Various forms of panels made of window shell. (Courtesy of Philippine Shell-Craft Corporation.)

PLATE 14

- FIG. 1. Kapis lantern of fanciful design. (Courtesy of Philippine Shell-Craft Corporation.)
2. Kapis lantern of modernistic design. (Courtesy of Philippine Shell-Craft Corporation.)

PLATE 15

- FIG. 1. Kapis inverted shade of modernistic design. (Courtesy of Philippine Shell-Craft Corporation.)
2. Kapis special inverted shade. (Courtesy of Philippine Shell-Craft Corporation.)

PLATE 16

Four types of table lamps made from window shell. (Courtesy of Philippine Shell-Craft Corporation.)

PLATE 17

Completely set dining table with various novelties from window and pearl shells and green snail. (Courtesy of Philippine Shell-Craft Corporation.)

PLATE 18

- FIG. 1. Shields made of rufo shell, or saddle oyster shell, *Placuna (Placenta) sella* Gmelin. (Courtesy of Philippine Shell-Craft Corporation.)
2. Direct rufo shade. (Courtesy of Philippine Shell-Craft Corporation.)

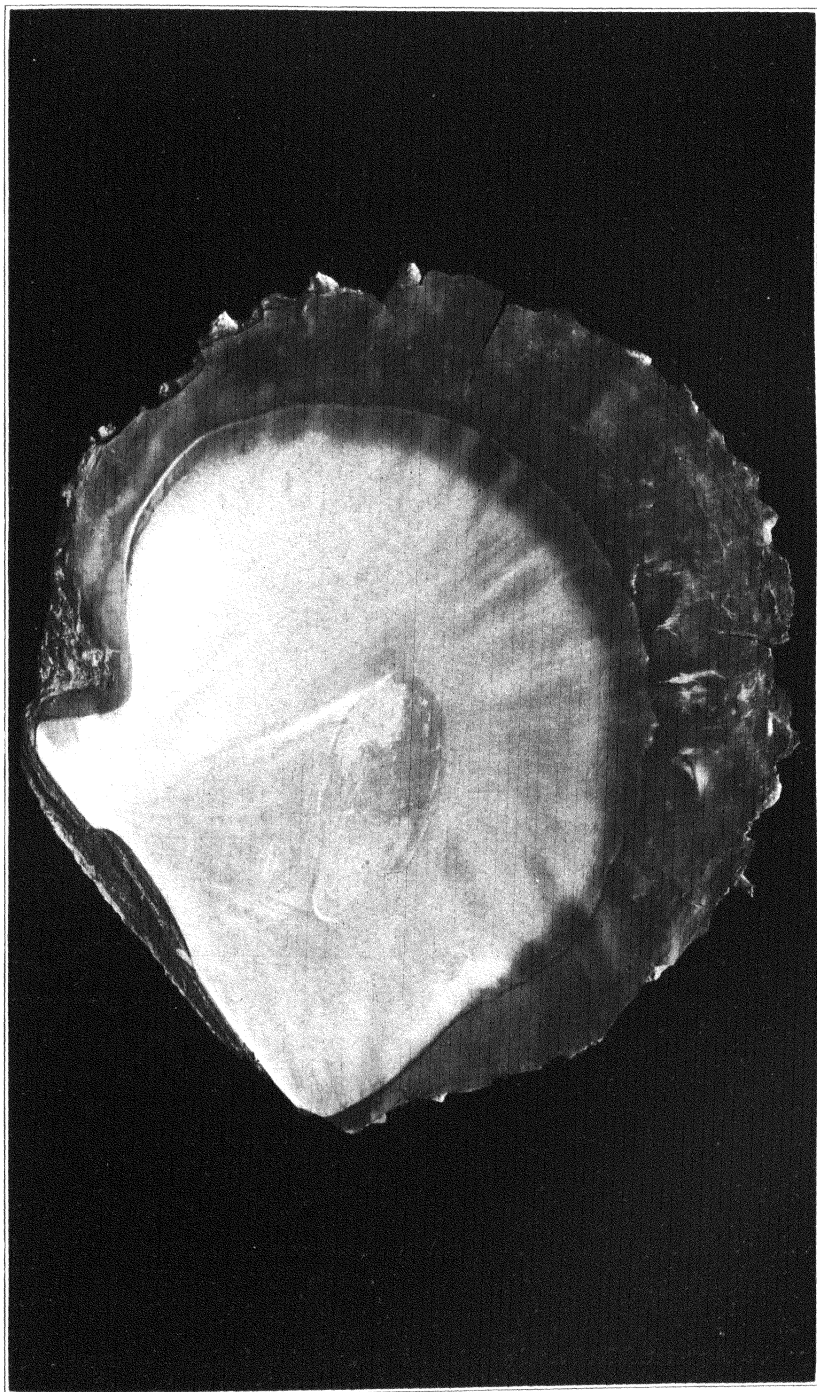
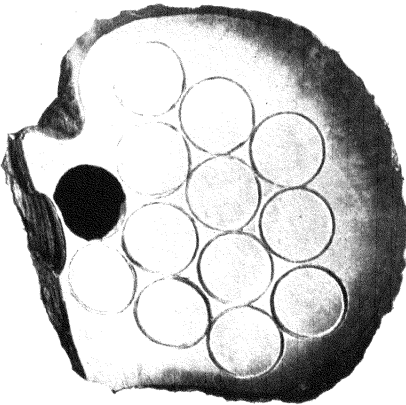


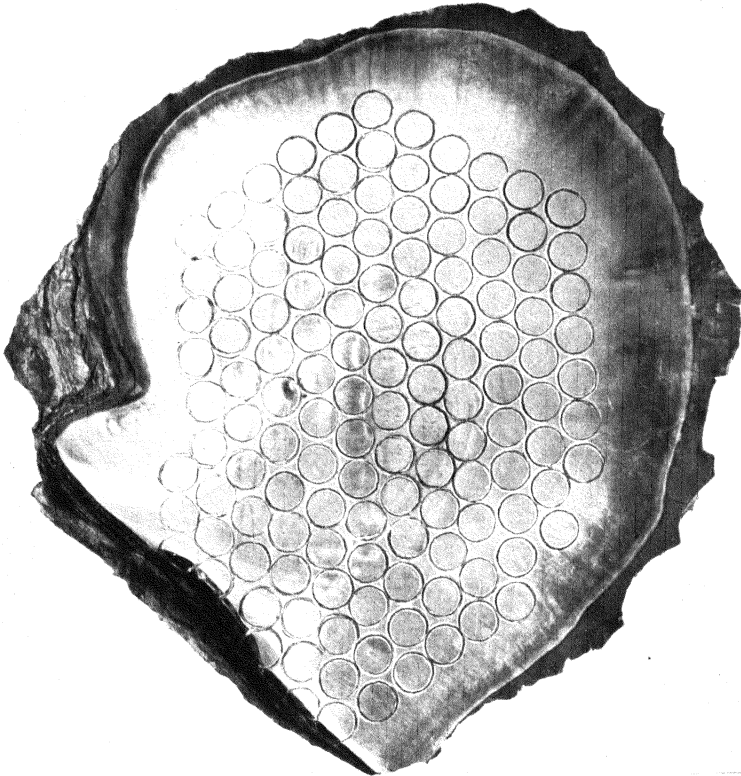
PLATE 1.



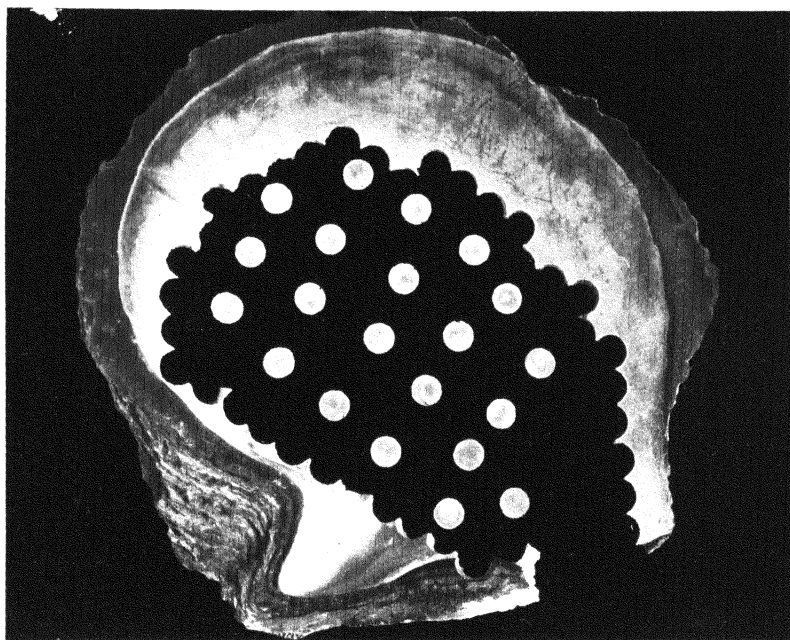
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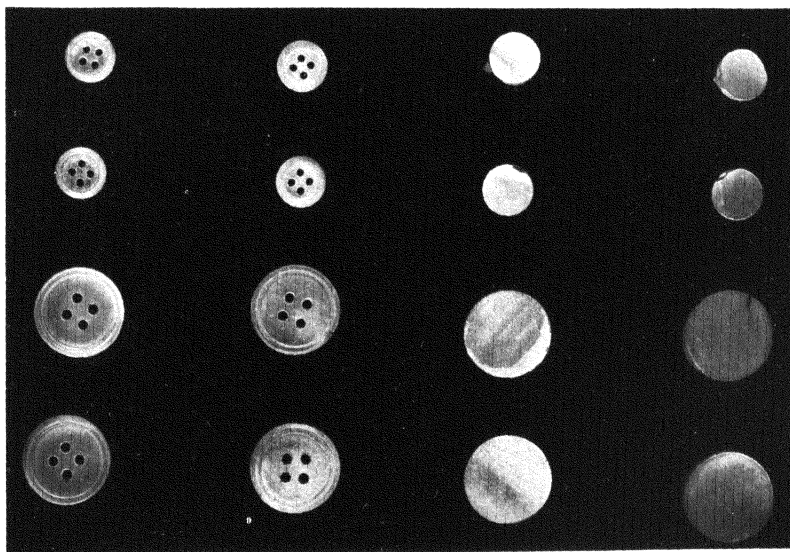
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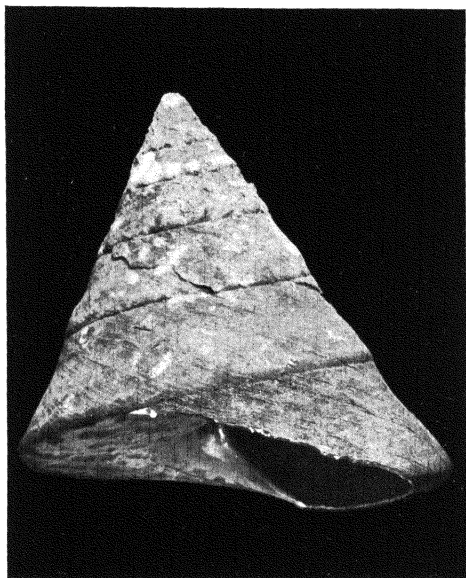
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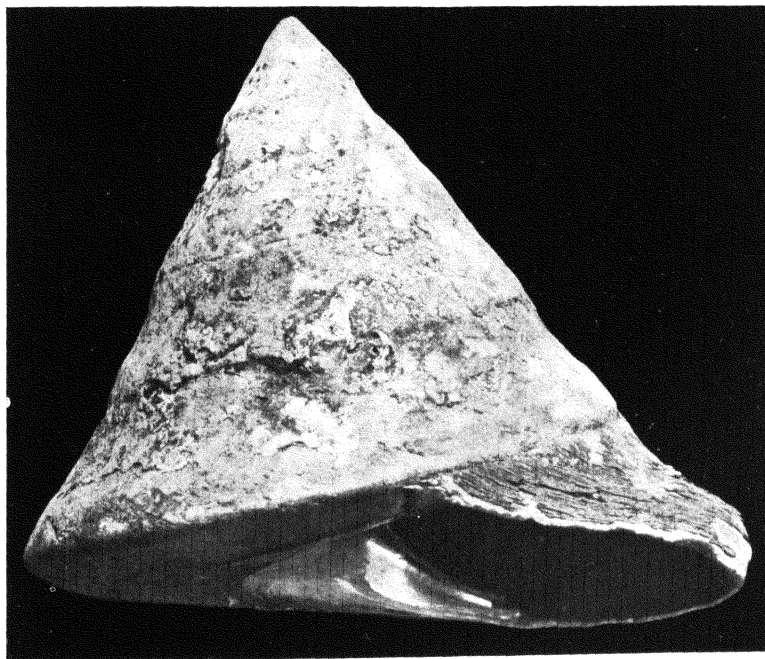
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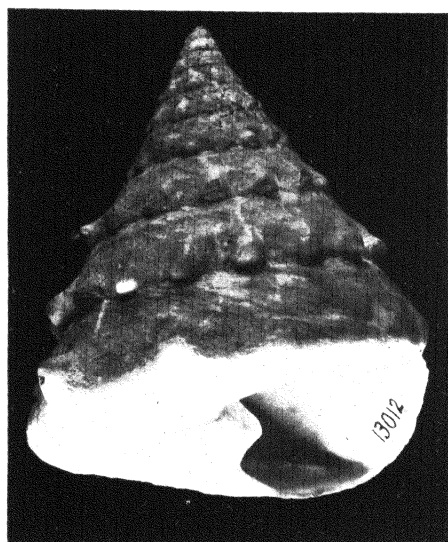
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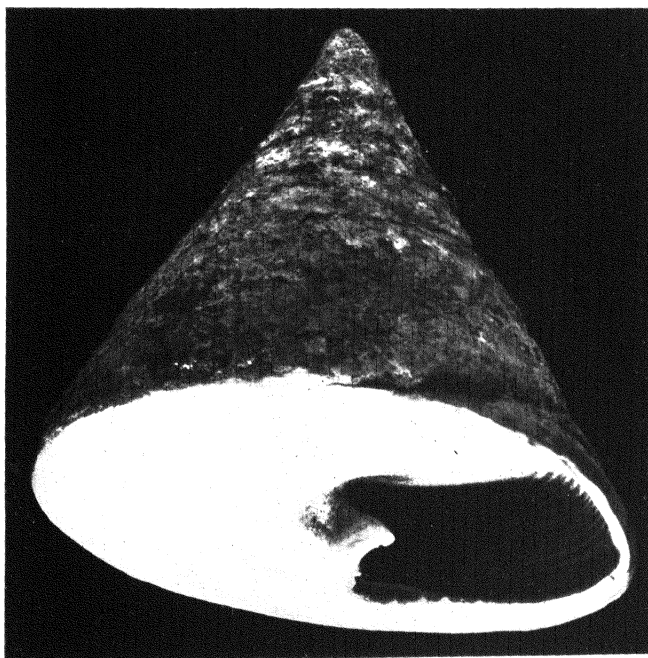
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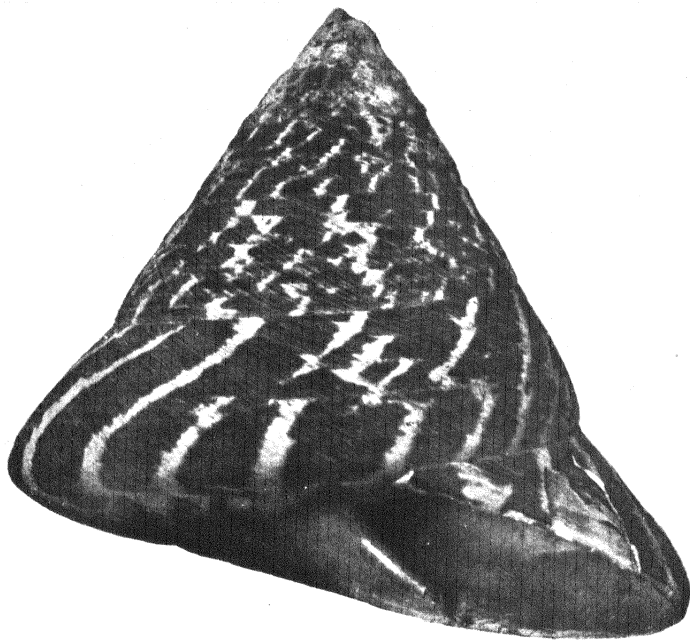
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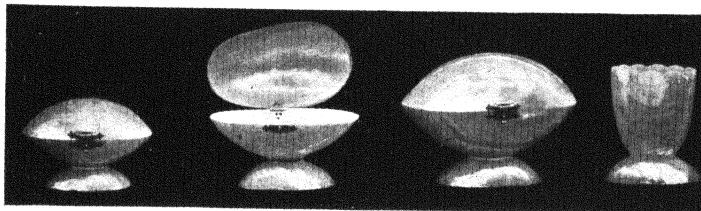


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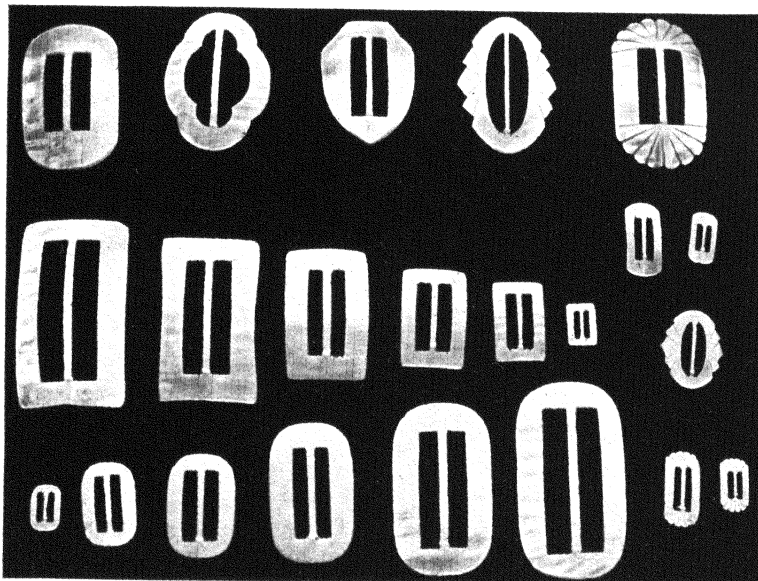
PLATE 7.



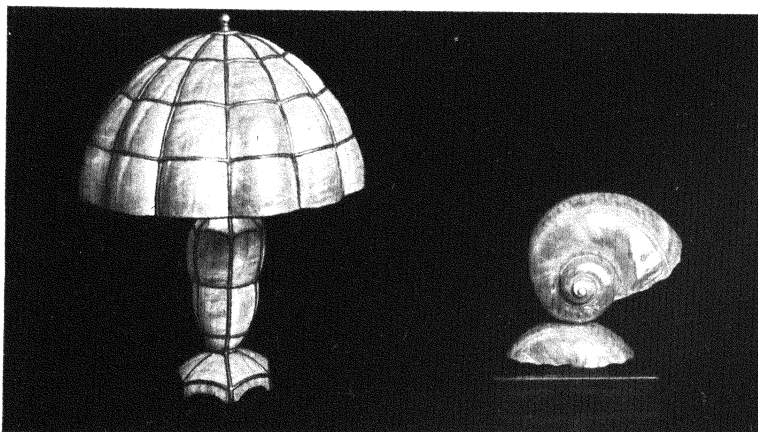
PLATE 8.



1



2



3

4

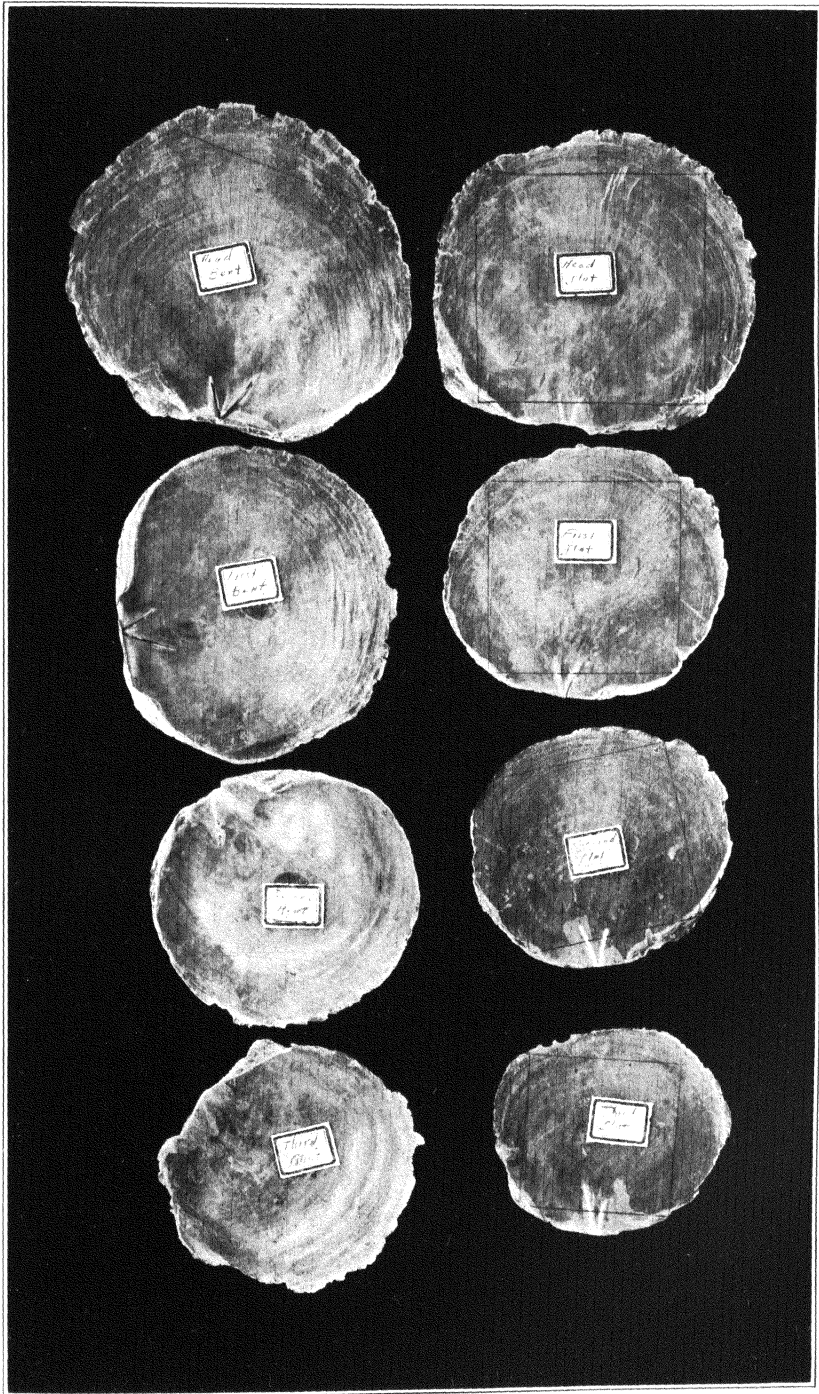
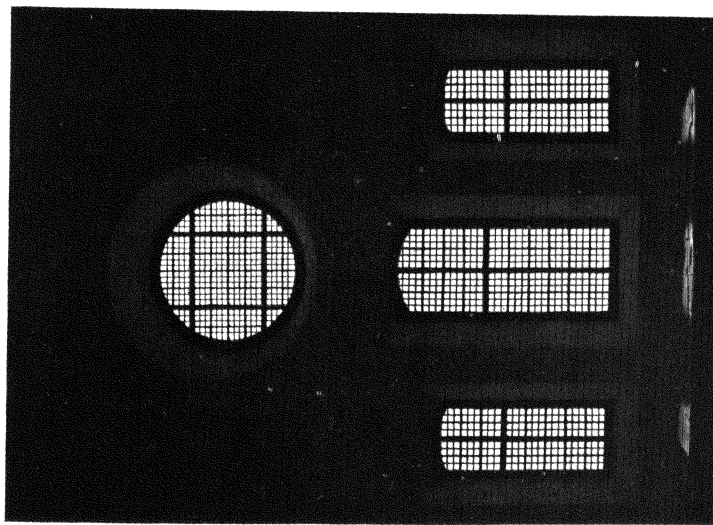
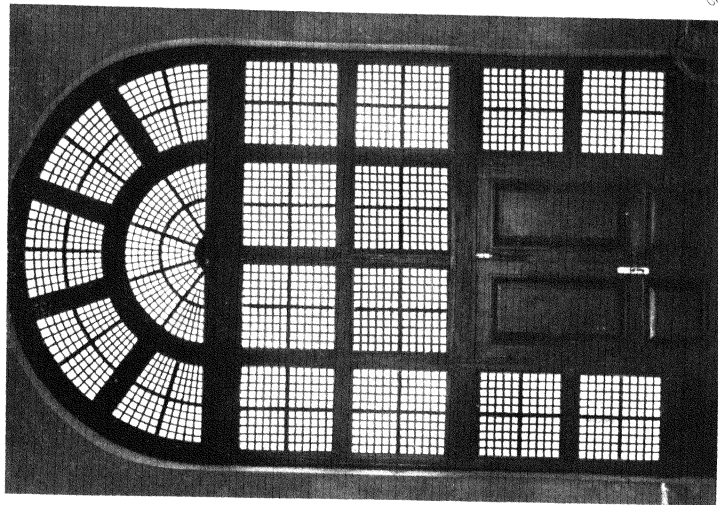


PLATE 10.



1



2

PLATE 11.

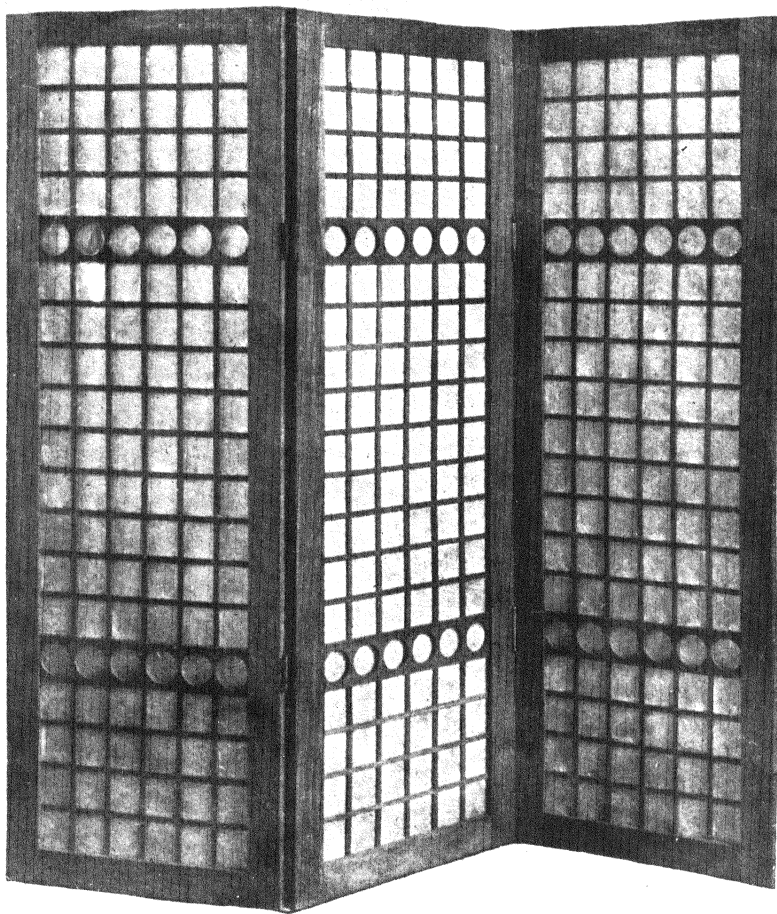


PLATE 12.

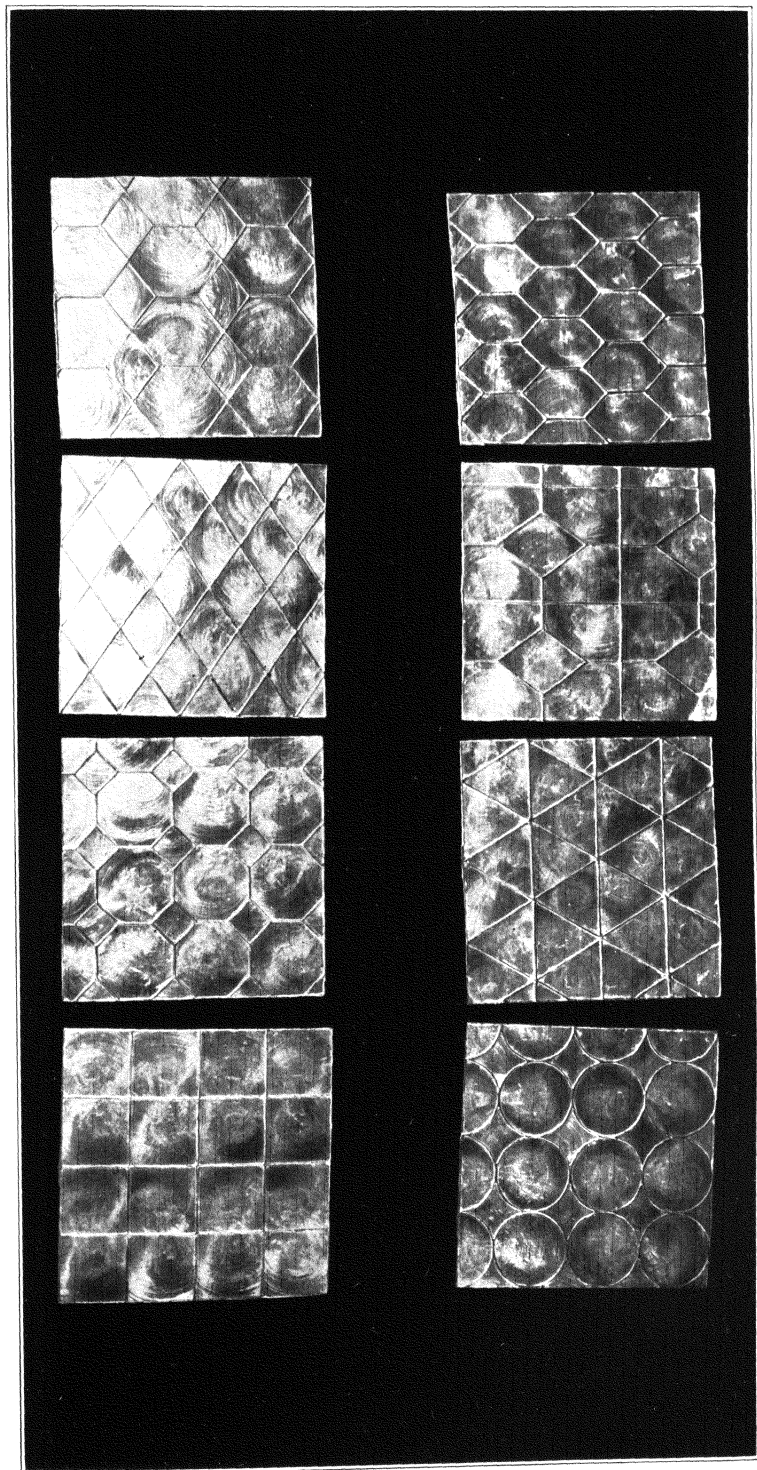


PLATE 13.



PLATE 14.

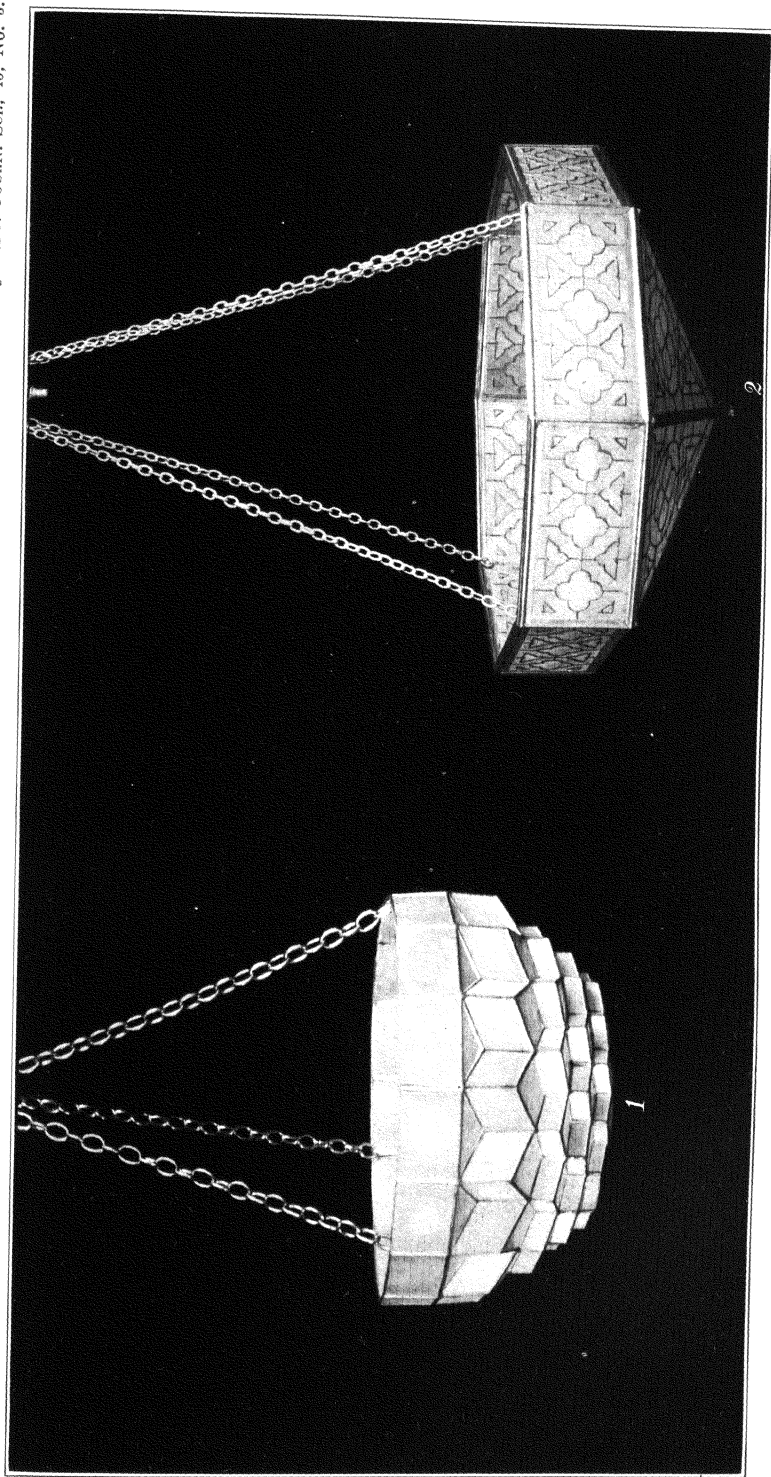


PLATE 15.

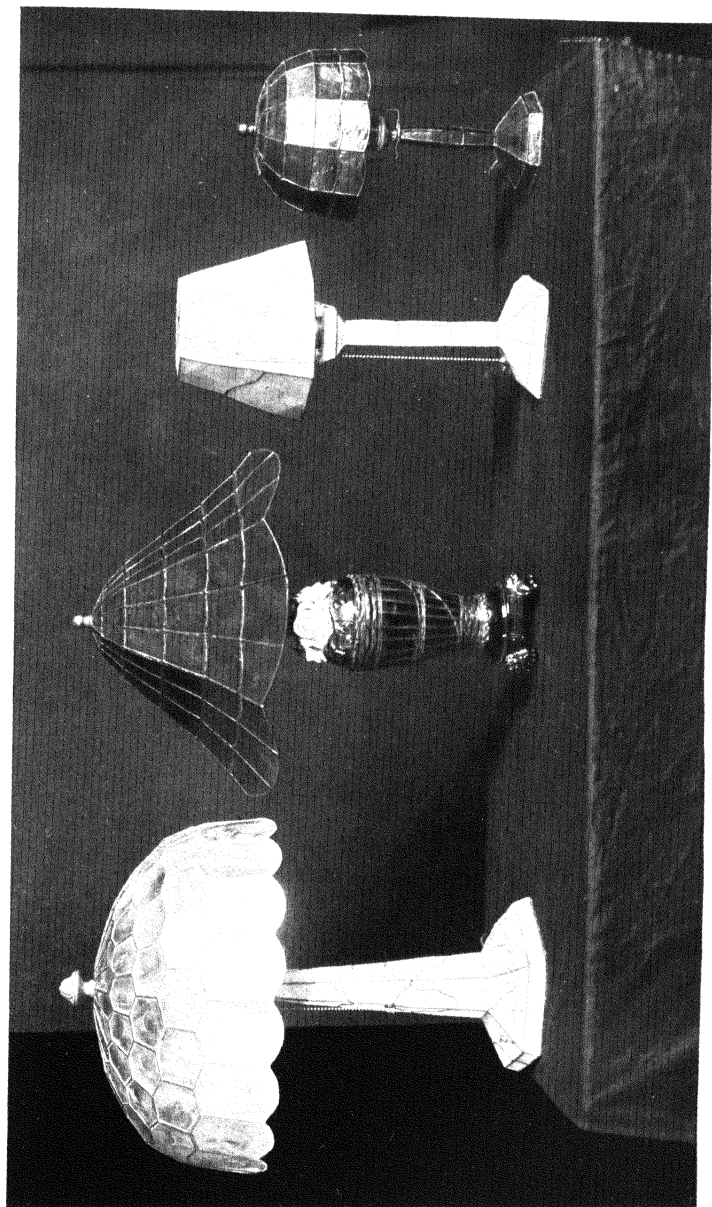


PLATE 16.

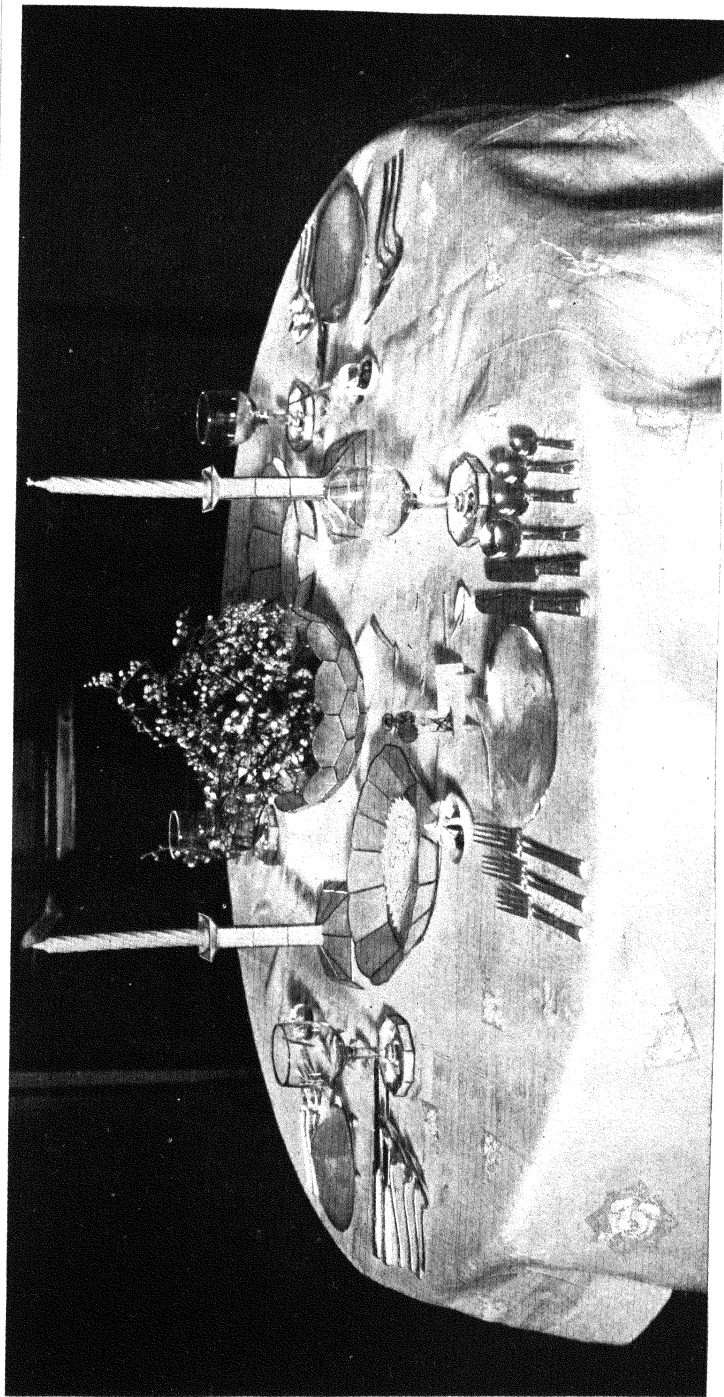
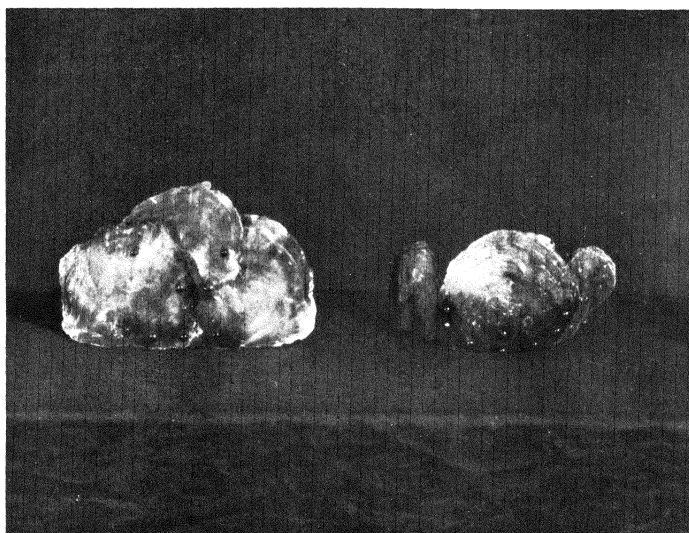
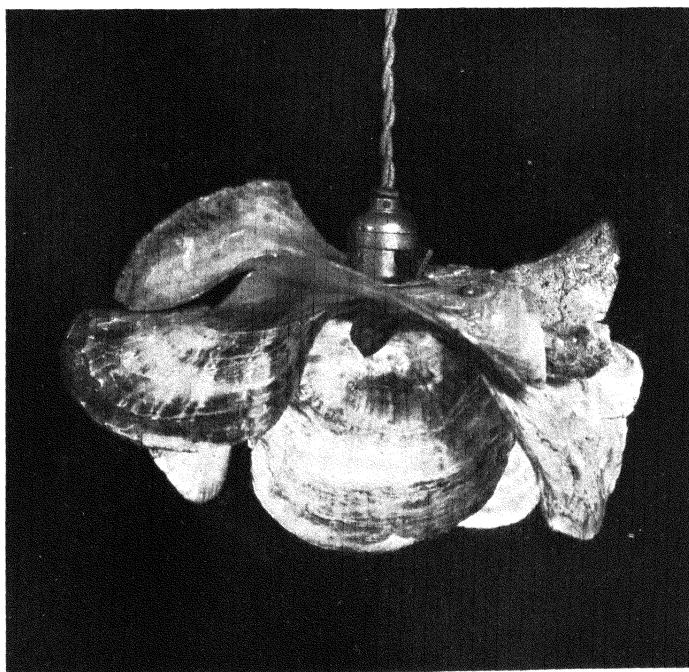


PLATE 17.



1



2

A NEW PARASITE OF PHILIPPINE AMPHIBIA ¹

By A. C. WALTON

Of Knox College, Galesburg, Illinois

ONE TEXT FIGURE

During the examination of a lot of *Oxysomatium* material obtained from amphibian hosts, attention was drawn to a species that seemed specific to a Philippine frog, *Rana magna* (?), and that differed distinctly from any species of that genus yet reported from Oriental amphibian hosts.²

The body proportions of the two sexes are usually differentiated, the male being relatively slender for its length and the female relatively stout. Both sexes taper gradually cephalad; caudad they taper gradually to the anal region and then rather abruptly to a very marked spikelike extension of the tail. The three lips are low and very poorly differentiated, each showing a pair of indistinct papillæ. No trace of buccal armature is distinguishable. The pharyngeal musculature is well set off from that of the œsophagus. The latter terminates in a distinct bulbar enlargement, showing an anteriorly flaring neck at the point of attachment to the œsophagus. Distinctly chitinized cutting plates are present in the bulbar region. The bulbar canal opens through flaplike valves into the dilatated anterior end of the intestine. The excretory pore opens slightly anterior to the neck of the œsophageal bulb. The posterior end of the male bends sharply ventrad and shows six pairs of preanal, two pairs of adanal, and two (three) pairs of postanal sessile papillæ; a rather unusual placing of the caudal papillæ in members of the genus *Oxysomatium*. The spicules are subequal, simple, and short. The accessory piece is well chitinized, though very small. The vulva opens slightly cephalad of the middle of the body. The muscular ovejector is "S"-shaped, passing cephalad before dividing into its two divergent branches. The eggs contain well-differentiated larvæ while still in the uteri. This species is probably oviparous, the larvæ hatching soon after oviposition.

¹ Contribution from the Knox College Biological Laboratories, No. 33.

² Morishita, K., Journ. Fac. Sci. Imp. Univ. Tokyo, Sec. IV 1 (1926) 1-32, pls. 1-5.

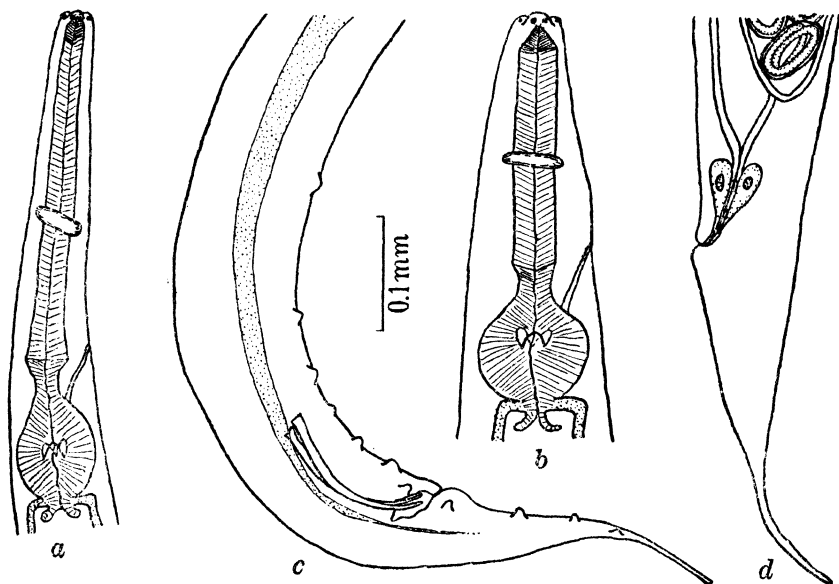


FIG. 1. *Oxysomatium ranæ* sp. nov.; male, anterior end, dorsal aspect; b, female, anterior end, dorsal aspect; c, male posterior end, lateral aspect; d, female, posterior end, lateral aspect. All figures are to the same scale. (Drawing by Walton.)

AVERAGE MEASUREMENTS

Male.—Body length, 2.5 millimeters; greatest width, 0.086; length of pharynx, 0.035; length of œsophagus, excluding bulb, 0.34; bulb, 0.055 by 0.065; nerve ring, 0.225 millimeter from the lips; excretory pore, 0.36 millimeter from the lips; cloaca-tail distance, 0.225; spicules, 0.16; accessory piece, 0.025; length of caudal spike, 0.09.

Female.—Body length, 3.8 millimeters; width at vulva, 0.23; length of pharynx, 0.03; length of œsophagus, excluding bulb, 0.265; bulb, 0.065 by 0.085; nerve ring, 0.15 millimeter from the lips; excretory pore, 0.28 millimeter from the lips; vulva-anus distance, 2; anus-tail distance, 0.23; length of caudal spike, 0.1; embryonated eggs, 0.056 by 0.076.

This hitherto undescribed species taken from the intestines of specimens of *Rana magna* (?), a Philippine frog, is here named *Oxysomatium ranæ* sp. nov.

The type specimens are in the collection of Dr. H. B. Ward, University of Illinois, Urbana, Illinois.

ILLUSTRATION

TEXT FIG. 1. *Oxysomatium ranæ* sp. nov.; *a*, male anterior end, dorsal aspect; *b*, female, anterior end, dorsal aspect; *c*, male, posterior end, lateral aspect; *d*, female, posterior end, lateral aspect. All figures are to the same scale. (Drawings by Walton.)

THREE NEW SAND FLIES FROM THE PHILIPPINES ¹

By C. MANALANG

Of the Philippine Health Service, Manila

THREE TEXT FIGURES

In March, 1930, three male recumbent-haired sand flies were caught in the vicinity of Bigti camp, Angat-Novaliches water project, Bulacan Province, Luzon. Potash preparation showed a bell- or pear-shaped pigmented area on the dorsal wall of the buccal cavity. In May three flies (two females and one male) with pigmented areas identical to those of the male from Bigti were sorted out of the flies sent from Malinao, Camarines Sur. In June a female was caught in Bigti with pigmented area of the same shape.

From the barrio of Dayap, Laguna, came a collection that contained a female with a mushroom-shaped pigmented area. Collections from Sipocot and Ragay, Camarines Sur, also showed a few females with the same shape of pigmented area but with wing veins and teeth somewhat similar to those of the female.

Towards the end of April, 1930, Dr. Vicente Torrechante, of the division of malaria control, sent me a large collection of sand flies from Sipocot, Camarines Sur Province, in which was found a female with a very dark funnel-shaped pigmented area. In his subsequent collection from Apali and Malinao of the same province, a male and a female with this type of pigmented area were also found.

The three species of sand flies are recumbent-haired while their males have the *minutus* type of genitalia. As far as I can find out, they possess a combination of characters different from those already described for sand flies from the Philippines and other Oriental countries. Therefore, I propose to name them *Phlebotomus bigtii*, *P. dayapensis*, and *P. torrechantei*. The following descriptions are based entirely on potash preparations mounted in Berlese's fluid. The spermatheca are not described because the preparations did not show them clearly.

¹ From the field laboratory, division of malaria control, Philippine Health Service, Tungkong Manga, Bulacan.

PHLEBOTOMUS BIGTII sp. nov. Fig. 1.

FEMALE

A large species; body length, 2.85 to 2.95 millimeters; wings long, broad, and asymmetrical.

Palps.—First segment one-half the length of the second; third segment longer than the fourth; second and fourth segments about equal; the combined lengths of the second and third segments may be either slightly greater or less than the length of the fifth. Total length, 0.53 to 0.58 millimeter (fig. 1, e).

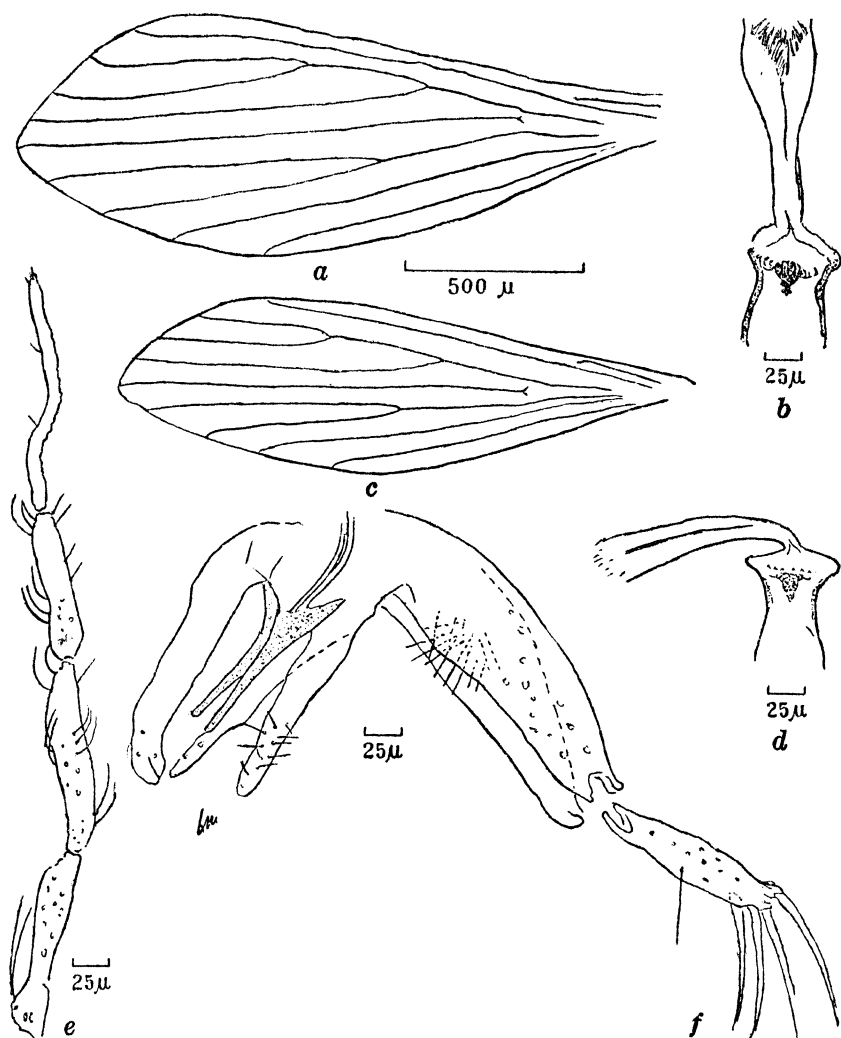


FIG. 1. *Phlebotomus bigtii* sp. nov.; a, wing, female; b, buccopharynx; c, wing, male; d, pharyngeal bulb; e, palps; f, genitalia.

Antennæ.—Incomplete and denuded in the two specimens examined.

Buccopharynx.—Buccal cavity with dark bell- or pear-shaped pigmented area. Armature with one row of ten to twelve long bent pointed teeth present. Pharyngeal bulb with a thick brush of spines (fig. 1, b).

TABLE 1.—*Measurements of Phlebotomus bigtii* sp. nov. in millimeters.

	Female 1.	Female 2.	Male 1.	Male 2.
Body:	mm.	mm.	mm.	mm.
Clypeus and head.....	0.300	0.350	0.275	0.300
Thorax.....	0.575	0.550	0.400	0.450
Abdomen.....	1.900	1.800	1.400	1.300
Superior clasper, segment 1.....	0.175	0.150	0.250	0.250
Total length.....	2.950	2.850	2.325	2.300
Labium.....	0.280	0.250	0.175	0.200
Antenna:				
Segment III.....	0.350	0.350	0.400	0.400
Segment IV.....	0.137	0.150	0.175	0.175
Segment V.....	0.137	0.150	0.175	0.175
Segment VI.....	0.137	0.150	0.175	0.175
Segments XII to XVI.....			0.425	0.450
Segments I, II, and VII to XI.....		0.900	1.000	1.000
Total length.....			2.350	2.375
Palp:				
Segment 1.....	0.050	0.050	0.037	0.025
Segment 2.....	0.100	0.100	0.087	0.087
Segment 3.....	0.125	0.125	0.112	0.112
Segment 4.....	0.112	0.100	0.100	0.112
Segment 5.....	0.250	0.212	0.225	0.237
Total length.....	0.637	0.587	0.561	0.603
Wing:				
Length.....	1.900	2.000	1.700	1.700
Width.....	0.650	0.650	0.450	0.500
Hind leg:				
Femur.....	0.760	0.800	0.650	0.700
Tibia.....	1.400	1.425	1.230	1.350
Tarsus segment 1.....	0.725	0.725	0.650	0.700
Tarsi 2 to 5.....	0.800	0.800	0.700	0.750
Total length *.....	3.685	3.750	3.230	3.500
Superior clasper, male:				
Segment 1.....			0.250	0.250
Segment 2.....			0.112	0.125
Intromittent organ.....			0.087	0.087

* Not including coxa and trochanter.

Thorax and abdomen.—No scales on the pleuræ. Hairs erect on the dorsum of the thorax and first abdominal segment but recumbent on the other segments.

Wings.—Voluminous, with the anterior border slightly more curved than the posterior. Relative lengths of important veins

vary in different individuals but α is conspicuously long, being slightly shorter only than the combined lengths of β or γ or $2 \times \beta$ while δ is distinctly longer than either β or γ . Wing, 1.9 to 2 millimeters long, 0.65 millimeter wide (fig. 1, *a*).

Hind legs.—Total length 1.2 to 1.3 times the length of the body. Total length, 3.6 to 3.7 millimeters.

MALE

Smaller than the female, total body length, 2.3 millimeters; short geniculate spines visible in the antennal segments. Relative lengths of wing veins different from the female in that α is much shorter than $\beta + \gamma$ while δ is distinctly shorter than either β or γ (fig. 1, *c*). The buccal armature and pigmented area are similar to those of the female except that the teeth are fewer and shorter. The spines in the pharyngeal bulb are few and slender (fig. 1, *d*).

Genitalia.—Typical of the *minutus* group with four stout basally pigmented pointed macrochætæ, two apical and two subapical. Intromittent organ paired; genital filaments not protruding (fig. 1, *f*).

PHLEBOTOMUS DAYAPENSIS sp. nov. Fig. 2.

FEMALE

A medium-sized species, 2.15 to 2.25 millimeters long; wings symmetrically lanceolate.

Palps.—First segment about one-half or more the length of the second; the third equal to the combined lengths of the first and second; fourth segment longer than the third; fifth segment about equal to the combined lengths of the second, third, and fourth segments in one female but shorter than the third and fourth in another. Total length, 0.66 to 0.74 millimeter (fig. 2, *e*).

Antennæ.—Segment III 2.5 times segment IV and shorter than the combined lengths of segments XII to XVI. Short geniculate spines are present.

Buccopharynx.—Buccal cavity with mushroom-shaped pigmented area. Teeth number 24, more or less, their points numerous and like the teeth of a saw. Pharyngeal bulb long; flask-shaped, without armature at its œsophageal extremity (fig. 2, *b*).

Thorax and abdomen.—Similar to the preceding species. Total body length including clypeus, 2.15 to 2.25 millimeters.

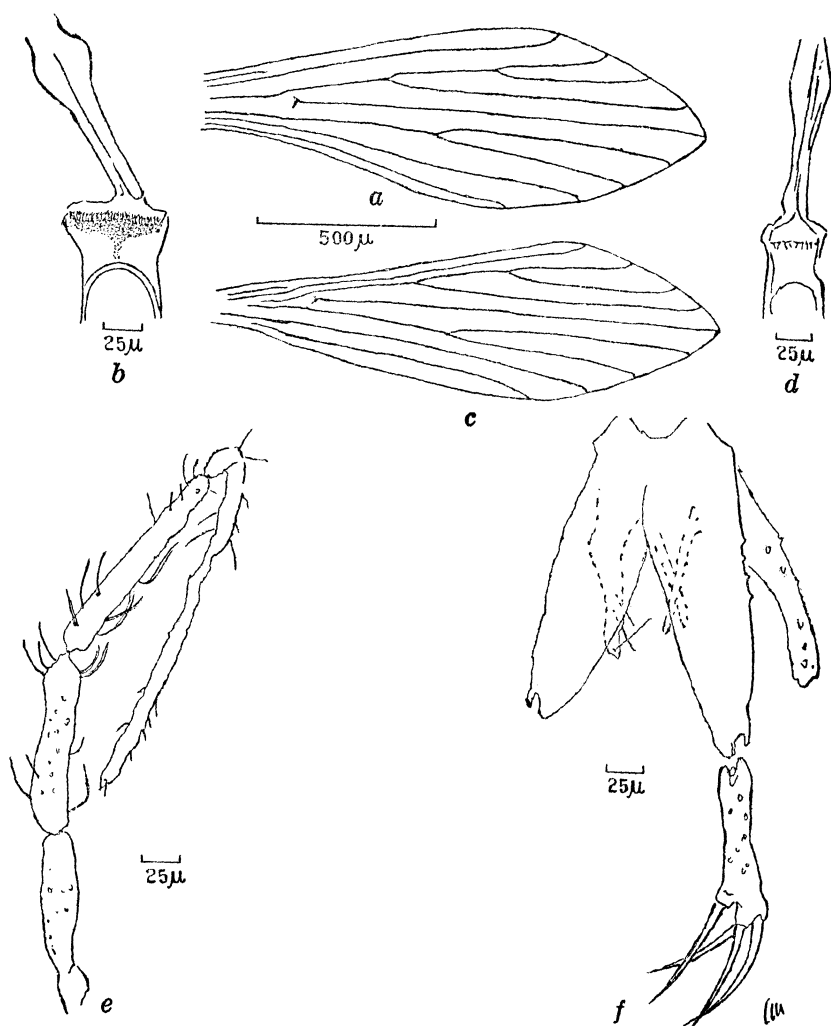


FIG. 2. *Phlebotomus dayapensis* sp. nov.; a, wing, female; b, buccopharynx; c, wing, male; d, pharyngeal bulb; e, palps; f, genitalia.

Wings.—Anterior and posterior curvatures alike. Relative length of important veins are: $a = \beta$; a or $\beta = 2 \times \delta$; $\gamma > \beta$.

Hind legs.—Total length, 1.1 to 1.2 times the total length of the body. Total length is 2.5 to 2.6 millimeters.

MALE

Smaller than female; antennæ longer with longer geniculate spines; palps distinctly shorter. Wing veins are as follows: a longer than β ; β , γ , and δ are all about equal. Buccal armature

TABLE 2.—*Measurement of Phlebotomus dayapensis* sp. nov. in millimeters.

	Female 1.	Female 2.	Male 1.	Male 2.
Body:	mm.	mm.	mm.	mm.
Clypeus and head.....	0.300	0.275	0.300	0.300
Thorax.....	0.500	0.500	0.400	0.400
Abdomen.....	1.000	1.350	1.100	1.100
Superior clasper segment 1.....	0.150	0.130	0.237	0.250
Total length.....	2.150	2.255	2.037	2.050
Labium.....	0.200	0.200	0.125	0.175
Antenna:				
Segment III.....	0.250	0.250	0.300	0.300
Segment IV.....	0.100	0.100	0.125	0.125
Segment V.....	0.100	0.100	0.125	0.125
Segment VI.....	0.100	0.100	0.125	0.125
Segment XII to XVI.....		0.325		0.350
Segments I, II, and VII to XI.....		0.637	0.750	0.750
Total length.....		1.512		1.775
Palp:				
Segment 1.....	0.037	0.050	0.037	0.025
Segment 2.....	0.075	0.075	0.075	0.066
Segment 3.....	0.125	0.125	0.087	0.091
Segment 4.....	0.158	0.160	0.087	0.075
Segment 5.....	0.350	0.250	0.175	0.150
Total length.....	0.745	0.660	0.461	0.417
Wing:				
Length.....	1.600	1.600	1.550	1.400
Width.....	0.460	0.460	0.450	0.425
Hind leg:				
Femur.....	0.630	0.650	0.650	0.600
Tibia.....	0.950	0.900	1.100	0.925
Tarsus segment 1.....	0.450	0.425	0.560	0.500
Tarsi segments 2 to 5.....	0.600	0.550	0.600	0.600
Total length *.....	2.630	2.525	2.910	2.625
Superior clasper, male:				
Segment 1.....			0.237	0.250
Segment 2.....			0.100	0.100
Intromittent organ.....			0.087	0.087

* Not including coxa and trochanter.

without pigmented area, with fewer, broader, and less-pointed teeth than those in the female (fig. 2, *d*).

Genitalia.—Similar to the preceding species. The distal segment of the superior clasper is armed with four nonpigmented, pointed macrochætæ, three apical and one subapical (fig 2, *f*).

The wing venation and pigmented area in the buccal cavity of this species are similar to those of *P. taianensis* Patton and Hindle,² but the morphology and arrangement of the macrochætæ of the male terminalia are different. *Phlebotomus taianensis* has more than twice as many teeth in the buccal cavity.

² Proc. Royal Soc. Sec. B 102 (1928) 533-551.

PHLEBOTOMUS TORRECHANTEI sp. nov. Fig. 3.

FEMALE

Medium sized, the body measuring 2.4 millimeters. Wings voluminous and almost symmetrical; antennæ and legs relatively long.

Palps.—Second segment twice the length of the first; fourth segment longer than the second but slightly shorter than the

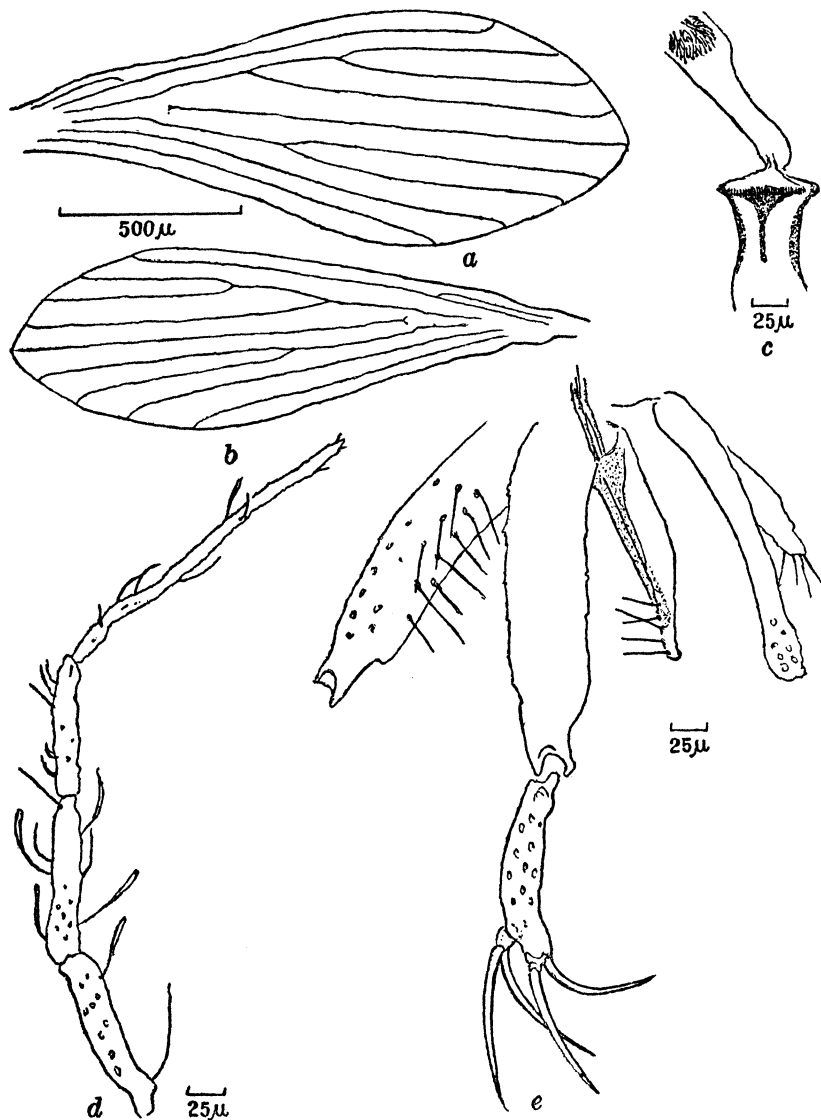


FIG. 3. *Phlebotomus torrechantei* sp. nov.; a, wing, female; b, wing, male; c, buccopharynx; d, palps; e, genitalia.

third; fifth segment slightly longer than the combined lengths of third and fourth segments (fig. 3, *d*).

Antennæ.—Segment III is about 2.5 times segment IV and shorter than the combined lengths of segments XII to XVI. Geniculate spines present.

Buccopharynx.—The dark pigmented area in the buccal cavity is funnel-shaped, with a long stem. The teeth are numerous, slender, and side by side like a fine comb. The œsophageal end of the pharyngeal bulb carries a brush of stout spines (fig. 3, *c*).

Thorax and abdomen.—Similar to those of the two preceding species.

TABLE 3.—Measurements of *Phlebotomus torrechantei* sp. nov. in millimeters.

	Female 1.	Female 2.	Male 1.
Body:	mm.	mm.	mm.
Clypeus and head.....	0.350	0.350	-----
Thorax.....	0.500	0.500	0.475
Abdomen.....	1.400	1.400	1.300
Superior clasper, segment 1.....	0.150	0.150	0.230
Total length.....	2.400	2.400	-----
Labium.....	0.200	0.200	-----
Antenna:			
Segment III.....	0.387	0.387	0.400
Segment IV.....	0.150	0.150	0.150
Segment V.....	0.150	0.150	0.150
Segment VI.....	0.150	0.150	0.150
Segments XII to XVI.....	0.475	0.430	0.560
Segments I, II, and VII to XI.....	0.900	0.925	0.900
Total length.....	2.212	2.192	2.310
Palp:			
Segment 1.....	0.037	0.037	0.033
Segment 2.....	0.075	0.062	0.075
Segment 3.....	0.112	0.116	0.108
Segment 4.....	0.100	0.100	0.100
Segment 5.....	0.225	0.225	0.206
Total length.....	0.549	0.540	0.522
Wing:			
Length.....	1.700	1.750	1.600
Width.....	0.650	0.600	0.500
Hind leg:			
Femur.....	0.850	-----	0.700
Tibia.....	1.200	-----	1.160
Tarsus segment 1.....	0.600	-----	0.550
Tarsus segments 2 to 5.....	0.750	-----	0.675
Total length ^a	3.400	-----	3.085
Superior clasper:			
Segment 1.....	-----	-----	2.230
Segment 2.....	-----	-----	0.125
Intromittent organ.....	-----	-----	0.087

^a Not including coxa and trochanter.

TABLE 4.—Differential characters of the three new species and the other local species of the *Phlebotomus minutus* group.

Area or organ.	<i>P. micric</i> Banks.	<i>P. mangenus</i> Ma- nalang.	<i>P. hitchesi</i> Ma- nalang.	<i>P. heiseri</i> Ma- nalang.	<i>P. bighi</i> sp. nov.	<i>P. dayapensis</i> sp. nov.	<i>P. torrechantei</i> sp. nov.
Female:							
Buccal armature— Pigmented area.....	Cylindrical.....	Triangular.....	None.....	Triangular (pale)	Bell-shaped.....	Mus h r o m- shaped. One row, 24 or more, n o t pointed.	Funnel-shaped. One row, many slender, not separate, not pointed. Thick brush of spines.
Teeth.....	Two or more rows, few con- ical and sep- arate.	One row, very manyslender, not separate.	One row, about 10 separate, low and con- ical.	Two rows; an- terior short, posterior long.	One row, 10 to 12 long sepa- rate, pointed.	No spines.....	
Pharyngeal bulb, posterior end.....	Several rows of slender spines pointing back- wards.	Many long fila- ments spines point- ing back- wards.	No spines.....	Thick brush of long stout spines.	Thick brush of long stout spines.		
Wing, α and β	$\alpha = \beta$	$\alpha = 2 \times \beta$	$\alpha = 2 \times \beta$	$\alpha > \text{or} < 2\beta$	$\alpha > 2\beta$	$\alpha = \beta$	$\alpha < 2\beta$.
Spermathecae.....	Barrel-shaped.....	Barrel-shaped.....	Bottle-shaped.....	Pear-shaped.....			
Male:							
Buccal armature— Pigmented area.....	None.....	None.....	None.....	Same as female.	Same as female.....	None.....	Same as female.
Teeth.....	Fewer, larger, and separate than in female.	Fewer, larger, and separate than in female.	Same as female.	Fewer than female.	Fewer and shorter than female.	Fewer and shorter than female.	Do.
Genitalia; macrochaetae.....	Three apical, one subapical (pigmented).	All apical (pig- mented).	Two apical, two subapical (not pigmented).	Two apical, two subapical (not pigmented).	Two apical, two subapical (pig- mented).	Three apical, one subapical (not pig- mented).	Two apical, two subapical (pig- mented).
Mesial surface proximal segment, superior clas- per.	With thick brush of long stout hairs.	None.....	Brush of slen- der hairs.	Thin brush of long hairs.	Thin brush of long slender hairs.	Thin brush of long slender hairs.	Thin brush of long slender hairs.

Wings.—Voluminous and symmetrical venation characterized by long α and δ and relatively short β and γ so that $\alpha < \beta + \gamma$ or 2β , while δ is just a trifle shorter than $\beta + \gamma$ (fig. 3, *a*).

Hind legs.—Total length 1.4 times the body. Total length, 3.4 millimeters.

MALE

Only one male has been examined. Palp is shorter while the antenna is longer than those of the female. Wings are symmetrical as in the female but α is not so long, it being shorter than the combined lengths of β and γ ; β , γ , and δ are all about the same length (fig. 3, *b*). Buccopharyngeal armatures are similar to those of the female but with fewer teeth in the buccal cavity and fewer spines in the pharynx.

Genitalia.—Similar to those of the preceding two species. Macrochætæ pointed, pigmented basally, two apical, two sub-apical (fig. 3, *e*).

Table 4 gives the differential characters of the three new species and the other Philippine species of the *minutus* group.³

SUMMARY

1. Three new species of Philippine *Phlebotomus* of the *minutus* group are described, and the important differential characters are given.

³ Manalang, C., Philip. Journ. Sci. 41 (1929) 175; 42 (1930) 283-305.

ILLUSTRATIONS

TEXT FIGURES

- FIG. 1. *Phlebotomus bigtii* sp. nov.; *a*, wing, female; *b*, buccopharynx; *c*, wing, male; *d*, pharyngeal bulb; *e*, palps; *f*, genitalia.
2. *Phlebotomus dayapensis* sp. nov.; *a*, wing, female; *b*, buccopharynx; *c*, wing, male; *d*, pharyngeal bulb; *e*, palps; *f*, genitalia.
3. *Phlebotomus torrechantei* sp. nov., *a*, wing, female; *b*, wing, male; *c*, buccopharynx; *d*, palps; *e*, genitalia.

MALARIA TRANSMISSION IN THE PHILIPPINES, II
INFECTION OF ANOPHELES FUNESTUS GILES² (MINIMUS) WITH
NOTES ON ITS DENSITY, PROBABLE RANGE OF FLIGHT,
AND LARVAL CONTROL¹

By C. MANALANG

Of the Philippine Health Service, Manila

ONE TEXT FIGURE

A preliminary survey for natural malaria infection in about 2,700 anophelines caught in La Mesa and South Portal camps, Novaliches water project, Rizal Province, Luzon, in 1927 has already been reported.³ Twenty-seven of 2,283 *Anopheles funestus* (*minimus*) were found infected. The figures submitted were not satisfactory, and the different species dissected were not numerically well represented. In the preceding paper, more-conclusive figures based on a two-year observation on about 65,000 mosquitoes with twelve species were given. They were caught in eight camps of the water project and the barrios of San Francisco del Monte and Novaliches. For the localities observed, which are topographically and entomologically typical of nearly every known malarious district in the Philippines, the observation was conclusive that *A. funestus* is the most important natural malaria vector. Laurel's⁴ preliminary work on blood meals of *funestus* shows that 79.43 per cent of them were of human origin. The other species bit either cows or horses. If malaria control in the Philippines is ever to succeed through mosquito reduction, a thorough knowledge of the factors influencing the vector, favorably or otherwise, is indispensable.

The present paper is based on data collected from January, 1928, to May, 1930, on *A. funestus* caught in South Portal camp (see fig. 1), a temporarily inhabited area of the water project, and where over 200 positives were found. The place being

¹ From the field laboratory, division of malaria control, Philippine Health Service, Tungkong Manga, Bulacan.

² Manalang, Philip. Journ. Sci. 43 (1930) 247.

³ Manalang, Philip. Journ. Sci. 37 (1928) 123.

⁴ Monthly Bull. Philip. Health Serv. 10 (1930) 153-166.

malarious, Paris-green control of *funestus* breeding (streams) and quinine prophylaxis were instituted following the opening of the camp in 1927. Infected *funestus* had already been caught in this camp and with the prospect that the work would continue for some time, it became a suitable place for study. The camp is about 20 kilometers northeast of Manila, some 100 meters above sea level, hilly, mostly covered with cogon grass, with scattered trees, and cut by permanent and temporary (rainy season) streams. The banks of the streams are lined with trees and bushes or bamboo.

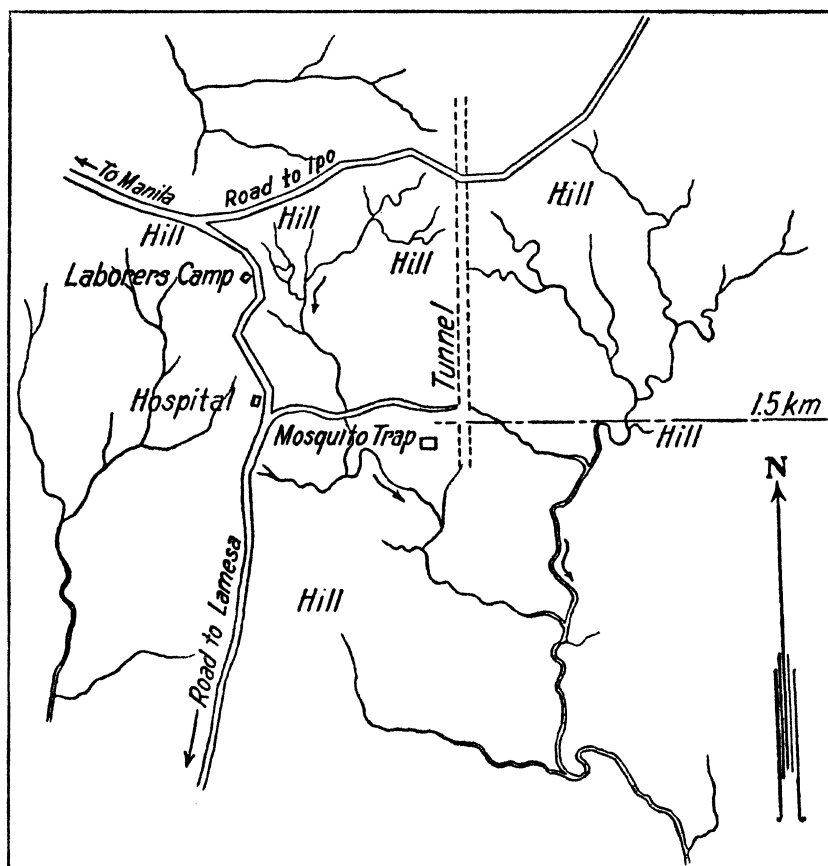


FIG. 1. Sketch map of South Portal.

INHABITANTS, MALARIA CASES, AND BLOOD FINDINGS

The laborers, who formed the bulk of the population and from whom the mosquitoes obtained malaria constantly, changed from camp to camp and fluctuated in number between 70 and 322. Many of them had already had malaria the year before. Table

TABLE 1.—Population and malaria cases at South Portal.

Month.	1928					1929					1930				
	Popula- tion.	Relap- sing cases.	Nonre- lapsing cases.	Total.		Popula- tion.	Relap- sing cases.	Nonre- lapsing cases.	Total.		Popula- tion.	Relap- sing cases.	Nonre- lapsing cases.	Total.	
					P. ct.					P. ct.					P. ct.
January.....	70	4	1	5	7.00	210	10	0	10	4.76	161	4	6	10	6.20
February.....	77	0	0	0	0.00	115	3	4	7	6.00	303	6	4	10	3.30
March.....	110	0	0	0	0.00	245	3	12	15	6.10	209	6	0	6	2.80
April.....	106	3	0	3	2.80	284	7	1	8	3.00	100	1	0	1	1.00
May.....	102	9	0	9	8.80	226	14	0	14	6.10					
June.....	116	0	10	10	8.60	287	14	10	24	8.36					
July.....	110	4	0	4	3.60	268	9	5	14	5.00					
August.....	90	16	0	16	17.00	322	9	3	12	3.70					
September.....	141	16	0	16	11.34	272	8	7	15	5.50					
October.....	141	10	2	12	8.50	267	7	4	11	4.10					
November.....	159	3	3	6	3.80	(*)	(*)	(*)	(*)	6.50					
December.....	130	6	5	11	8.40	170	8	3	11	6.50					
Total.....		71	21	92			92	49	141			17	10	27	

* Data lost.

1 shows the monthly population and malaria cases.⁵ The figures represent admissions, not individuals, and show that about two-thirds of the cases had suffered repeated attacks during the month. Their quarters were of bamboo, roofed with cogon or tin, and unscreened. Very few used mosquito nets. Quinine-prophylaxis compliance on the part of the laborers was at times doubtful, as shown by the very low percentage of positive Mayer's test in the urine of those who claimed to have taken the drug, and by not infrequently finding tablets of quinine on the road. Infirmary cases usually resumed work as soon as their symptoms disappeared although many still carried the parasites, particularly gametes. The influence of the neighboring camps, La Mesa to the south and North Portal to the north (both with

TABLE 2.—Blood smears from surveys and cases.

SURVEYS.			
Date.	Exam'ned.	Positive.	
			Per cent.
September, 1928.....	40	3	7.5
September, 1929.....	91	18	19.78
March, 1930.....	130	1	0.70
INFIRMARY CASES.			
1928.....	* 178	86	35.4
1929.....	* 265	94	48.3

* Number of examinations; not individual cases

malaria and under larval control and quinine prophylaxis), on the malaria in man and mosquito in South Portal cannot be estimated but must have been considerable. Large animals were not allowed in the area. It is evident that the incidence of malaria in man and *A. funestus* in this camp may not have been as natural as that obtaining in localities with a permanent population that leads a normal life, and where no control measures are instituted. Even if blood smears were taken at frequent regular intervals, the parasite rates would not be a satisfactory criterion to evaluate the results of antilarval control measures due to the changing population and quininization. Blood examinations are given in Table 2. Thick and thin smears

⁵ From the reports of the physician in charge, Dr. Modesto Castillo, under supervision of Dr. A. Ejercito. Dr. Raymond Miller took charge from January, 1930.

were used. *Plasmodium vivax* was slightly more predominant than *P. falciparum*. No *P. malaria* was found. For reasons already known to most students of malariology, case records and blood findings need not necessarily show correlation with mosquito infection.

MOSQUITO CATCHES AND DENSITY

Table 3 gives the monthly catches during the period of observation, which averaged twenty-three days a month. The influence of larval control on the adult density is not known. During January and February, 1928, 924 *A. funestus* were caught by exposure as they were only rarely found in the houses. From March till December, 4,341 were caught in the human-baited trap, or a total of 5,265 *funestus* for 1928; 1,260 for 1929; and only 56 from January to May, 1930. No males were caught in this trap at any time.⁶ The trap was located in a valley not far from a stream, and in the center of the Paris-green control area with a radius of 1.5 kilometers. It was a small wire-screen house, 2.5 by 2.5 by 2.5 meters, with screen ceiling and four doors. Mosquitoes that entered between 7 and 10 p. m. were spotted on the screen with a flashlight and covered with a test tube. The catcher slept under a mosquito net, with or without a light in the trap, and with the doors open till 4 a. m. when they were closed. The trapped mosquitoes were caught in the morning and sent to Manila with those caught during the night, daily except holidays. The dead and weak were identified and dissected at once, while the live ones were transferred into wide-mouthed ounce bottles with a pledget of cotton saturated with water or dilute glucose water and stored in a refrigerator at 23 to 25° C. At this temperature, they were inactive and lived long enough to allow some positive blood meals to develop into oöcysts. From September, 1929, the mosquitoes were dissected in the field laboratory at Tungkong Manga. A mosquito net about the size of the trap with a long slit opening on one side was used successfully in North Portal and Tungkong Manga. For adult mosquito surveys of different places, this portable trap is the most convenient. Trapping of *A. funestus*, which is an "out-of-doors" species, has the following advantages over expo-

⁶ The catches from March, 1928, indicate the monthly density since they were collected in the same trap by one man exposed during a definite period of time. There is no information on the difference in trap catches with one or two men in the trap. Difference in individual attractiveness has not been studied. Laurel's work, however, shows that *A. funestus* has marked avidity for man.

TABLE 3.—*Monthly Anopheles funestus* catch and infections in South Portal.

Month.	1928				1929				1930			
	Positive.				Positive.				Positive.			
	Mosqui- toes caught.	Sto- mach.	Salivary gland.	Total infected. <i>P. ct.</i>	Mosqui- toes caught.	Sto- mach.	Salivary gland.	Total infected. <i>P. ct.</i>	Mosqui- toes caught.	Sto- mach.	Salivary gland.	Total infected. <i>P. ct.</i>
January.....	723	9	4	13 1.8	93	0	1	1 1.0	37	0	0	0
February.....	201	3	3	6 3.0	65	2	0	2 3.0	5	0	0	0
March.....	567	7	6	13 2.3	90	3	4	7 7.7	6	0	0	0
April.....	498	3	8	11 2.2	170	1	1	2 1.2	7	0	0	0
May.....	562	16	17	33 5.8	124	2	2	4 3.2	1	0	0	0
June.....	469	6	11	17 3.6	313	2	0	2 0.6				
July.....	735	23	10	33 4.5	148	0	0	0 0.0				
August.....	490	16	7	23 5.0	81	1	0	1 1.2				
September.....	371	8	7	15 4.0	43	0	0	0 0.0				
October.....	671	9	2	11 1.7	29	0	0	0 0.0				
November.....	255	3	2	5 1.9	47	0	0	0 0.0				
December.....	223	4	6	10 3.6	57	1	0	1 1.8				
Total.....	5,765	107	83	190	1,260	12	8	20	56	0	0	0

sure: The catcher does not contract the disease; personal equation is reduced to a minimum; catching is easier, with less chance of escape; being a circumscribed fixed unit, the collection is a reliable index of mosquito density and reveals the efficiency of larval control; the sporozoite rates in those caught will explain the prevalence of malaria among the susceptibles and the causes of certain behaviors of malaria incidence, which are at present obscure.

FLIGHT RANGE AND LARVAL COLLECTIONS

The difficulty of rearing *A. funestus* from larva or catching and maintaining alive for a few days several thousands of them precluded direct flight observation on stained mosquitoes. It would be expensive and impractical to measure *funestus* density in the centers of several nearly identical well-supervised Paris-green control areas, each with a different radius, the catches simultaneous and under the same meteorological conditions. It is far simpler to observe the flight range of mosquitoes breeding in a solitary marsh or fishpond by catching them at different distances at the same time.

The object of larval control is to reduce the density of the transmitter as much below the minimum effective number in the locality as possible. This number is variable, as will be shown in the following article, and is inversely proportional to the number and accessibility to the mosquito of suitable malaria-gamete carriers. The most that could be observed in South Portal was to determine if the economic radius of Paris-green control (1.5 kilometers) was effective in reducing *funestus* density so that those systematically caught during a reasonable period would no longer show infection.

Table 2, of monthly trap catches during the period of observation, shows a distinct decrease in their density from November, 1928, or, after ten months of trapping, a period apparently too distant to have any relation to the larval control that was begun in 1927. The reduced catch continued through 1929 and five months of 1930. Unfortunately, there was no record of monthly adult catches previous to the larval control. What would have been the catches during the entire period of observation had Paris green not been used is not known. The longest time *A. funestus* has been kept alive under artificial conditions was about one month. Whether they live longer in nature or not is unknown. For the two months after larval control was suspended (April and May, 1930) only eight *funestus* were caught

in the trap. The catches show an apparent natural decrease in density since November, 1928. Similar decrease has been observed in two other places under larval control.

A record was kept of the weekly number of larvæ caught at five definite stations on the streams in the area to check the efficiency of spraying. Throughout the period of observation (dippings in portions of the streams other than the stations) larval breeding in the control area was practically nil at times, and invariably much less than the breeding beyond the control limits. Estimation of larval density by their number per dip was unsatisfactory, due to the marked variation in breeding and the depth of the water in which they breed, a condition also observed in uncontrolled streams. The findings of pupæ and full-grown larvæ were an indication that the spraying was not done or at least not thorough. Table 4 shows the monthly number of larvæ thus collected.⁷ It will be noted that the larvæ collected were few during the period of high adult catches, and relatively many in the latter half of 1929 and in 1930 when the adult catches were low. It is, therefore, probable that most of the *funestus* caught in the trap had migrated from their distant breeding places into the control area. The discorrelation between anopheles larval breeding and adult density, regardless of the proximity of man, has already been observed in the other localities and cannot be explained. Gater⁸ had a similar experience with *A. aconitus* Donitz (a species closely related to *funestus*) in Malaya. Barber⁹ states that *aconitus* is capable of long flight. Hackett,¹⁰ who visited the Philippines in 1928 said, "In seven days spent in the Islands, I did not catch a single one (*minimus*) although a sporting colleague offered as high as a peso apiece for adult specimens. At the same time the larvæ were abundant." Swellengrebel,¹¹ writing on anophelism for the Malaria Commission of the League of Nations in their tour through eastern Europe and Italy, May to September, 1924, relates their experiences with *A. maculipennis* as follows:

Often we could not find any larvæ in collections of water apparently suitable for breeding, not only where these had been petrolised or dealt

⁷ Compiled from the reports of the physician in charge.

⁸ Ann. Report, Inst. for Med. Res. Kuala Lumpur, F. M. S. (1927) 29.

⁹ Philip. Journ. Sci. 13 (1918) 1.

¹⁰ So. Med. Journ. 22 (1929) 367-371.

¹¹ League of Nations Health Organization. Malaria Commission. Report on its Tour of Investigation in Certain European Countries in 1924. Geneva (1925) 174.

TABLE 4.—Monthly catches in the larval stations at South Portal.^a

Month.	1928				1929				1930						
	Small.	Medium.	Large.	Pupa.	Total.	Small.	Medium.	Large.	Pupa.	Total.	Small.	Medium.	Large.	Pupa.	Total.
January-----	280	118	62	0	460	19	28	6	0	53	200	124	68	0	392
February-----	756	513	238	0	1,507	42	20	0	0	62	229	165	67	3	464
March-----	351	85	29	0	465	33	20	13	0	66	179	145	15	10	349
April-----	139	0	0	0	139	77	33	23	0	133	176	112	98	0	386
May-----	125	25	0	0	150	32	23	3	0	58	-----	-----	-----	-----	(b)
June-----	100	40	22	0	162	79	28	12	0	119	-----	-----	-----	-----	(b)
July-----	47	12	3	0	62	25	15	6	0	46	-----	-----	-----	-----	(b)
August-----	120	45	23	0	188	24	14	23	0	61	-----	-----	-----	-----	(b)
September-----	38	12	0	0	50	354	118	35	0	507	-----	-----	-----	-----	(b)
October-----	42	19	0	0	61	465	128	71	0	664	-----	-----	-----	-----	(b)
November-----	22	12	2	0	36	(c)	(c)	(c)	(c)	-----	-----	-----	-----	-----	(b)
December-----	22	8	0	0	30	135	112	27	0	274	-----	-----	-----	-----	(b)

^a Compiled from the monthly reports of Doctors Castillo and Miller. Incidence of *A. funestus* larvae as identified in the malaria laboratory: 1928, 94.2 per cent; 1929, 62.6 per cent; 1930, 46.5 per cent. The other species were *A. barbirostris* v. d. Wulp and *A. sinensis* Wied.

^b No collection.

^c Record lost.

with in another way but also where no anti-larval measures had been taken (*e. g.*, in Ilfov district and round Galatz in Roumania or on the outskirts of the town Schachtnaja, Russia), although anophelines were very numerous in stables, and in some cases the presence of males proved the presence of newly hatched broods. This shows that our means of ascertaining the presence of breeding-places were inadequate or that more distant breeding places, lying outside the range of immediate observations, influenced the local anophelism.

It may be that *funestus* migrates a long distance from the breeding place during the first few days of life when a blood meal is as yet not needed. It is also possible that even trapping fails to get them. There are no data on the influence of wind. From our present knowledge, it is probable that the flight range of *funestus* is more than 1.5 kilometers and renders the economic radius of Paris-green control ineffective, unless the breeding is strictly limited within the area under control, a rare condition to find in malarious regions. It is also obvious that an adult mosquito collection, preferably using a portable trap, is necessary and gives more information in regard to the density of the vector in a locality than the larval collection alone.

MOSQUITO INFECTION

Table 3 shows the number of *A. funestus* caught, dissected, and found infected in 1928 and 1929, which varied from 0.6 to 7.7 per cent (stomach and salivary glands combined) a month. Constant mosquito infection was demonstrable from January, 1928, till June, 1929, and then none was found till May, 1930 (excepting one infected mosquito each in August and December, 1929) when the monthly catch averaged only thirty-six for the nine negative months. The average monthly catch during the twenty positive months was 338. In Strickland's¹² observations on natural infections on 1,353 *funestus* caught by trapping in coolie lines in Cachar (Assam), April to November, 1927, positives were found from June to November with a monthly average of 215 and none was found in April and May among eight and fifty-two *funestus*, respectively. His monthly infection rates were from 2.6 to 5.5 per cent. The influence of quinization, the movement of the laborers and suitable carriers from one camp to another is not known. The diminution in catches is evidently one of the causes of the negative findings since old malaria cases were still present during the negative months (monthly rates

¹² Indian Journ. Med. Res. 17 (1929) 174-182.

of 1 to 6.2 per cent). Had more mosquitoes been captured, and the carriers been suitable and accessible, infection would have been found throughout the entire period of observation. The findings indicate that given a constant proportion of suitable parasite reservoirs and susceptibles, endemic, seasonal or epidemic malaria, or its disappearance in a community in the Philippines depends considerably on adult *funestus* density and not on temperature (monthly mean 23.9 to 27.8° C.). An analysis of data from the ten places studied, defining the meaning of the direct relationship of *funestus* density to the amount of malaria transmission, will be the subject of the following paper. The influence of meteorological factors on malaria transmission will also be dealt with separately. Whether or not there are places where *funestus* abounds with suitable carriers but with little or no malaria will have to be shown by careful blood and adult mosquito survey.

CONTROL MEASURES

The accompanying map (fig. 1) shows the South Portal control area. It was recommended by the Rockefeller Foundation representative¹³ that Paris green be sprayed on "all anopheles mosquito breeding places" and its use in several demonstration units was started in the latter part of 1926. In 1927¹⁴ larval control was limited to streams, the breeding places of *funestus*.

Weekly spraying of the streams with 1 per cent Paris green in road dust was carried on by three laborers and an inspector under the supervision of a field director and a physician. Paris-green mixture was biologically tested in the laboratory with proper control and was known to be able to kill at least 90 per cent of *funestus* larvæ in one hour.¹⁵ The streams were divided into sections so that each was sprayed once a week. A record was kept of the weekly number of larvæ collected from definite stations, to check the efficiency of spraying. With this arrangement, it was believed that there was efficient larval control. During floods spraying was stopped, as the larvæ were carried away. Every evening a sanitary inspector gave 10 grains of quinine sulphate to each person in the camp. The efficiency of this quinine prophylaxis has already been commented on.

¹³ Ann. Rep. Philip. Health Serv. (1926) 247-248.

¹⁴ Ann. Rep. Philip. Health Serv. (1927) 165.

¹⁵ Manalang, C., Monthly Bull. Philip. Health Serv. 7 (1927) 725.

COMMENTS

The finding of infected mosquitoes regularly from January, 1928, to June, 1929, shows that not only the mosquito control was ineffective, but the quinine prophylaxis as well, in so far as reducing the source of infection of both man and mosquitoes was concerned. Although quinine prophylaxis was not well received by the laborers, whatever amount they were forced to take probably contributed much in keeping them working although many were found to have parasites in their blood.¹⁶ The situation was made less serious because the population in South Portal was already immune and susceptibles were not imported.

Even if the larval control as carried out were successful and economical (the cost in the camp was 11.50 pesos per capita per annum, exclusive of quinine), the method requires a special trained personnel to do nothing but that work. It cannot be placed in the hands of the regular health personnel. Larval control with Paris green may be justified in projects that can afford to spend freely and for experimental purposes, provided the radius is more than 1.5 kilometers.¹⁷ The safe radius is unknown and may vary according to the peculiarities of the locality. Construction of portable mosquito-proof laborers' quarters by the contractor might have given better results. Quinization or, better still, the use of plasmochin compound, as tested by Ejercito,¹⁸ and treatment of cases should still be employed as the method of choice.

Anopheles funestus caught in the trap is a good index of the mosquito density and effectiveness of larval control, while a malaria survey of those caught is useful to evaluate antimalaria measures when the population is inconstant and periodical blood surveys are unreliable. It is also apparent that trapping of *funestus* as a control measure is not only impractical but ineffective.

The natural decrease in the density of adult *funestus* from November, 1928, till 1930 is very important in mosquito-control

¹⁶ See reference, footnote 3.

¹⁷ In April, 1931, Doctor Ejercito and Mr. Laurel contracted *falciparum* infections from *funestus* bites whose malarial infections were derived from human carriers living 2.5 kilometers away from their camp. In the May meeting of the Advisory Board for Malaria Control, it was agreed to extend the radius of larval control from 1.5 kilometers to 3 kilometers.

¹⁸ Journ. Philip. Is. Med. Assn. 9 (1929) 229.

projects as it could easily have been attributed to larval extermination. Disturbance of *funestus* density due to larval control is not known. Disturbance of *funestus* infection rates due to changes of population and quinine is also not known.

SUMMARY

1. Data on *Anopheles funestus* caught in a human baited trap in South Portal camp of Novaliches water project show malarial infection to have been present in them throughout 1928 and eight months of 1929. The infection rates varied from 0.6 to 7.7 per cent per month. The disturbance in infection rates due to movement of the population and to quininization is not known.

2. Infections were not found when the catches were reduced to an average of 36 *funestus* per month during the nine negative months, while the average monthly catch during the twenty positive months was 338, and shows that malaria transmission is mainly dependent on *funestus* density. Disturbance in adult *funestus* density due to antilarval measures is not known.

3. Natural diminution in adult *funestus* density has been noted and could not be attributed to larval extermination.

4. Adult *funestus* catches in the trap is an effective index of mosquito density and reveals the efficiency of larval control, while malaria survey of those caught may be used to evaluate antimalaria measures when the population is inconstant and periodical blood surveys prove unreliable.

5. The flight range of *funestus* is probably more than 1.5 kilometers, the economic radius of Paris-green control, and renders this method ineffective as a control measure. Trapping as a control measure is impractical and not effective.

6. The number of larvæ breeding in a locality does not necessarily indicate the adult density in the immediate vicinity of human habitation. An adult mosquito survey, preferably by trapping, should be a part of the anopheles mosquito survey.

ILLUSTRATION

TEXT FIG. 1. Sketch map of South Portal.

PHILIPPINE ROSIN
FROM *PINUS INSULARIS* (ENDLICHER)

By IRENE DE SANTOS and AUGUSTUS P. WEST

Of the Bureau of Science, Manila

and

J. FONTANOZA

Of the Bureau of Forestry, Manila

ONE PLATE

Benguet pine (*Pinus insularis* Endlicher) forms extensive forests in the mountain regions of northern Luzon. Some months ago we examined samples of resin tapped from the Benguet pine, and our results showed that turpentine of excellent quality and high pinene content¹ is obtained from it.

Recently we investigated the rosin content of Benguet pine resin and found the rosin to be of very high grade. The results are recorded in this paper.

Rosin (colophony) consists principally of organic acids, commonly called abietic acid, and a small percentage of neutral material termed resene. Rosin is used considerably in the manufacture of soap, and in the varnish industry for the preparation of varnishes and resinate driers. It is also used in the manufacture of rosin oil and in the paper industry for sizing paper. Rosin is also employed in the manufacture of other substances such as sealing wax, oil cloth, printing ink, matches, and for various other purposes.² Glycerinated rosin (ester gum) is used considerably in the manufacture of pyroxylin enamels and lacquers³ which is an industry that seems to be expanding rapidly.

During the year 1928 a total of more than nine hundred thousand barrels of rosin were consumed⁴ by industrial concerns in the United States while over one million barrels were exported.⁵

¹ Philip. Journ. Sci. 45 (1931) 233.

² Wyman, L., Florida Dept. Agr. Bull. 25 N. S. (1929) 42.

³ Wilson, S. P., Pyroxylin enamels and lacquers.

⁴ Chem. Met. Eng. 37 (1930) 196.

⁵ Yearbook U. S. Dept. Agr. (1930) 944.

Information concerning the cultivation of pine trees and the production and uses of turpentine and rosin is given by various Government publications such as farmers' bulletins on longleaf pine, slash pine, and pine nursery stock.⁶

Recently, there have appeared two articles⁷ which give a very good resumé of the present status and future prospects of the turpentine and rosin industry.

Methods for the preparation of high-grade abietic acid and derivatives, such as esters and nitro compounds, from pine-tree rosin are given in recent articles.⁸

Some years ago Brooks⁹ tested the rosin obtained from the resin of Benguet pine trees. The trees selected for procuring the resin were growing near Baguio, a summer resort situated at an elevation of about 1,500 meters in the mountain province of the Philippines. According to Brooks the Baguio pine rosin contains over 90 per cent abietic acid.

EXPERIMENTAL PROCEDURE

Since the tests, made some years ago by Brooks, gave very promising results it seemed desirable to continue this work.

During the spring of 1930, Foresters J. Fontanoza and P. D. Esguerra, of the Philippine Bureau of Forestry, tapped a number of Benguet pine trees in and near Baguio. The resin obtained from these trees was then shipped to the Bureau of Science laboratories in Manila where an investigation was made of it.

Table 1 gives the location and approximate diameter of the pine trees selected for this investigation. The dates of tapping the trees, number of chippings, and the yield of resin are also included. As shown by the data, trees of various sizes were selected for our experiments.

⁶ Mattoon, W. R., U. S. Dept. Agr. Farmers' Bull. 1256 (1922); 1486 (1926).

Wakeley, P. C., U. S. Dept. Agr. Leaflet 32 (1929); 35 (1929).

Wyman, L., Florida Dept. Agr. Bull. 25 N. S. (1929).

Hayes, R. W., and P. C. Wakeley, Louisiana State Univ. Bull. 21 N. S., No. 3, pt. 2 (1929).

Veitch, F. P., and V. E. Grotlisch, U. S. Dept. Agr. Bull. 898 (1920).

⁷ Speh, C. F., Journ. Chem. Ed. 7 (1930) 2322.

Bent, L. N., Journ. Chem. Ed. 7 (1930) 2365.

⁸ Kesler, C. C., A. Lowy, and W. F. Faragher, Journ. Am. Chem. Soc. 49 (1927) 2898.

Goldblatt, L. A., A. Lowy, and W. B. Burnett, Journ. Am. Chem. Soc. 52 (1930) 2132.

⁹ Philip. Journ. Sci. § A 5 (1910) 229.

TABLE 1.—*Location and diameter of Philippine trees selected for collecting Benguet pine resin.*

Tree No.	Location.	Diameter.*	Date of tapping.	Duration of chipping.	Number of chippings.	Yield of resin.
		cm.	1930	1930		g.
1	Forbes Park.....	40.5	Jan. 22....	Jan. 29 to July 30..	27	574.0
2	do.....	37.0	do.....	do.....	27	505.6
3	do.....	37.5	do.....	do.....	27	1,898.0
4	do.....	33.5	do.....	do.....	27	882.8
5	do.....	48.5	do.....	do.....	27	1,220.6
6	do.....	57.5	do.....	do.....	27	1,346.5
7	Irisan near Naguillian Road..	42.5	Feb. 10....	Feb. 17 to July 31..	27	1,137.9
8	do.....	41.0	do.....	do.....	27	883.2
9	do.....	35.5	do.....	do.....	27	1,779.5
10	do.....	34.0	do.....	do.....	27	975.4
11	do.....	46.0	do.....	do.....	27	2,463.6
12	do.....	57.0	do.....	Feb. 17 to July 30..	35	2,448.3
13	do.....	38.0	do.....	do.....	35	1,753.1
14	do.....	47.0	do.....	do.....	35	1,338.6
15	do.....	42.0	do.....	do.....	35	1,471.4
16	do.....	51.0	do.....	do.....	35	3,037.3
17	Pimmarioc, Trinidad.....	42.0	April 25..	May 2 to July 29..	34	1,123.6
18	do.....	62.0	do.....	do.....	34	3,683.1
19	do.....	64.5	do.....	do.....	34	1,001.6
20	do.....	61.0	do.....	do.....	34	1,136.8
21	do.....	66.0	do.....	do.....	34	917.4

* The diameters of the trees were measured at a height of 1.3 meters from the ground.

The cup-and-gutter method was employed by the foresters in tapping and chipping the pine trees. The procedure was essentially the same as that described some years ago by Herty¹⁰ except that somewhat different tools were used. For instance, instead of using a broad ax a heavy bolo served the same purpose. After the first cut (streak) is made in the trees, most of the resin flows out during the first day, usually, and very little is obtained during the next few days. When the first cut is extended by a second chipping the resin begins to flow freely again for another day. By making new chippings frequently and continually lengthening the original cut the tree continues to yield resin for some months. A day or so after a new chipping, when the exudation has practically stopped, the resin is then poured (dipped) from the tree cup into a permanent container.

As shown by the data (Table 1) the yield of resin from individual trees varies considerably.

¹⁰ U. S. Dept. Agr. Forest Service Bull. 40 (1903) 17.

Altogether, twenty-one trees were tapped. The total resin obtained from the first tapping of these trees was combined into a composite sample (composite 1). Subsequently a number of these trees were tapped a second time. When these various samples of pine resin were received in our laboratory in Manila, they were first steam distilled to separate the turpentine from the rosin. After distillation the turpentine was separated from the admixed water and dried with calcium chloride. After draining off the water the rosin was dried in desiccators. The percentage yields of turpentine and rosin obtained from the pine resin are given in Table 2.

TABLE 2.—*Turpentine and rosin obtained from Benguet pine trees.*

Sample. ^a	Turpen- tine.	Rosin.
	<i>Per cent.</i>	<i>Per cent.</i>
Tree 3.....	15.33	84.67
Tree 5.....	17.02	82.98
Tree 9.....	16.18	83.82
Tree 18.....	17.47	82.53
Composite 1.....	14.58	85.42
Composite 2.....	16.57	83.43
Composite 3.....	17.23	82.77
Average.....	16.34	83.66

^a Samples for trees 3, 5, 9, and 18 were obtained from a second tapping. Composite 1. Combined resin from the first tapping of trees 1 to 21. Composite 2. Combined resin from the second tapping of trees 18, 20, and 21. Composite 3. Combined resin from a second tapping of trees 10, 12, and 16.

According to Wyman¹¹ the yield of resin from pine trees varies considerably depending upon such factors as soil, weather, size of trees, species, etc. In general, the quantity of resin obtained from a tree varies directly with the size of the tree and the highest yields are obtained in the hot dry season which permits of long continuous working.

In Florida pine-tree resin, when distilled, yields an estimated average of one barrel of turpentine for three and a third barrels of rosin. Expressed in percentage that would be 23.09 per cent of turpentine to 76.91 per cent of rosin by volume. According to our results (Table 2), Benguet pine-tree resin gave 16.34 per cent of turpentine to 83.66 per cent of rosin by weight, which would be equivalent to 20.93 per cent of turpentine to 79.07 per cent of rosin by volume. This is about a barrel of turpentine to three and four-fifths barrels of rosin. It would seem that

¹¹ Florida Dept. Agr. Bull. 25 N. S. (1929) 33.

TABLE 3.—Analysis of Benguet rosin.

Sample. ^a	Tree—				Composite—			American colophony pale. ^b
	3	5	9	18	1	2	3	
Specific gravity.....	1.054	1.062	1.058	1.033	1.068	1.054	1.072	1.069
Melting point:.....								
Softens °C.....	105	107	104	58	98	55	95	
Melts °C.....	119	115	110	66	107	62	112	
Acid value:.....								
Titration with aqueous alkali (A).....	164.5	162.7	161.2	148.9	165.3	149.4	164.8	157.9
Titration with alcoholic alkali (a).....	164.2	161.9	160.8	148.7	161.2	149.4	164.6	154.0
Total saponification value (B).....	189.9	165.1	162.2	153.0	175.9	166.1	175.5	169.4
Ester value (B-A).....	25.4	2.4	1.0	4.1	10.6	16.7	10.7	11.5
Ester value (B-a).....	25.7	3.2	1.6	4.3	14.7	16.7	10.9	15.4
Unsaponifiable matter.....	4.54	4.84	4.6	6.82	6.68	6.71	4.35	9.25
Specific rotation A 30° C.....	-62.67	-46.02	-63.55	-41.17	-26.95	-42.73	-64.57	

^a Samples for trees 3, 5, 9, and 18 were obtained from a second tapping. Composite 1. Combined resin from the first tapping of trees 1 to 21. Composite 2. Combined resin from a second tapping of trees 18, 20, and 21. Composite 3. Combined resin from a second tapping of trees 10, 12, and 16.

^b Sample of pale American colophony analyzed by A. H. Allen and S. O. Richmond, Allen's Commercial Organic Analysis 4 (1925) 248.

in the Philippines the yield of turpentine from Benguet pine trees is somewhat less than in Florida while the yield of rosin is slightly greater.

Rosin obtained from the resin of Benguet pine is pale yellow and, when freshly prepared, has a slightly aromatic odor. In Table 3 are given the constants of Benguet rosin. There is also included for comparison some constants of American rosin. The data indicate that samples of Benguet rosin obtained from different trees seem to vary considerably in composition. It also appears that the amount of unsaponifiable matter in Benguet rosin is considerably less than in American rosin. According to Lewkowitsch¹² the unsaponifiable matter in rosin varies considerably. In American rosin it ranges from about 5 to 9 per cent and samples of French rosin gave values above 15 per cent. These figures are considerably higher than the values we obtained for Benguet rosin and in this respect it would seem that Benguet rosin is of better quality than American rosin.

Like American rosin, the melting point of different samples of Benguet rosin varies considerably, depending on the amount of rosin oil contained in the rosin.

Samples of abietic acid were prepared from Benguet rosin obtained from the resin of tree 9 (second tapping). In general, we followed the method used by Kessler, Lowy, and Faragher.¹³ Our procedure was as follows: Benguet rosin (150 grams) was dissolved in 95 per cent alcohol (562.5 cubic centimeters) and filtered. One and a half grams of extraneous material, such as small twigs, was thus removed from the rosin and a solution of the purified product was obtained. To this solution was then added 11 cubic centimeters of hydrochloric acid (36 per cent). The mixture was boiled on a water bath for about fifteen minutes. Half normal sodium hydroxide (438 cubic centimeters) was then added to neutralize the hydrochloric acid and also a fourth of the acid content of the rosin. The mixture was then heated on a water bath (reflux) for about a half hour, after which it was distilled to remove the excess alcohol. On cooling, the residue solidified to a white mass consisting of white needles. The residue was then filtered to eliminate the mother liquor and the crystals washed with a small quantity of alcohol. After draining repeatedly on filter papers the crystals were finally dried in a vacuum desiccator. The melting point was 165° to

¹² Chemical Technology and Analysis of Oils, Fats, and Waxes 1 (1921) 630.

¹³ Journ. Am. Chem. Soc. 49 (1927) 2898.

168.6° C., and the yield of this complex sodium salt of abietic acid was about 96 per cent.

To prepare abietic acid, a portion of the complex sodium salt was dissolved in warm glacial acetic acid, filtered, and allowed to crystallize. The abietic acid separated out as a slightly yellowish crystalline mass. The crystals were filtered and washed with a small amount of glacial acetic acid, after which they were allowed to drain on a porous plate, and then dried in a vacuum desiccator. The melting point of the crystals was 152° to 153.8° C. and the yield of abietic acid was about 74 per cent calculated on the weight of the sodium salt.

Abietic acid was found to be soluble in ethyl alcohol, acetic acid, acetic anhydride, chloroform, benzene, ether, and carbon bisulphide.

The molecular formula commonly assigned to the material known as abietic acid is $C_{20}H_{30}O_2$. An average of our determinations of the neutralization value of abietic acid gave 187.6. The molecular weight of abietic acid obtained from our neutralization value checks quite closely with the calculated value:

Calculated for $C_{20}H_{30}O_2$	Molecular weight.
Found	302.2
	299.1

We determined the specific rotation of our abietic acid in different solvents by dissolving 2.5 grams of abietic acid in 50 cubic centimeters of solvent and polarizing in a 200-millimeter tube. The results were as follows:

Solvent.	Specific rotation
	$A \frac{30^\circ C}{D}$
	Degrees.
Ethyl alcohol (95 per cent)	— 82.54
Benzene	— 3.6
Chloroform	— 63.47
Ethyl acetate	— 31.21
Acetone	— 79.42

According to the data above the rotation of abietic acid in different common solvents is negative and varies considerably. Virtanen¹⁴ obtained somewhat similar results with pinabietic acid.

The authors wish to thank Mr. Arthur F. Fischer, director of the Philippine Bureau of Forestry and Mr. Luis J. Reyes, chief of the division of forest products, Bureau of Forestry, for their

¹⁴ Virtanen, A. I., *Liebig's Annal. Chem.* 424 (1921) 150.

Rau, M. G., and J. L. Simonsen, *Ind. For. Rec.* 11 (1924) 210.

coöperation and assistance in this work on the chemistry of forest products.

The authors also wish to thank the forester, Mr. P. D. Esguerra, of the Philippine Bureau of Forestry, for his kindness in procuring samples of Benguet pine resin for this investigation.

SUMMARY

We have investigated the rosin obtained from the resin of Benguet pine trees growing at Baguio in the mountain province of the Philippines.

The yield of pine resin from these trees varies considerably.

The yield of Benguet rosin is somewhat larger than the yield obtained from the resin of Florida pine trees.

Samples of rosin from the pine resin of numerous Benguet trees seem to differ very much in composition.

The unsaponifiable matter of Benguet rosin is somewhat less than that of American rosin.

Like American rosin, the melting point of different samples of Benguet rosin varies considerably.

Samples of abietic acid were prepared from Benguet rosin. The yield of abietic acid calculated on the weight of the complex sodium salt of abietic acid was 74 per cent.

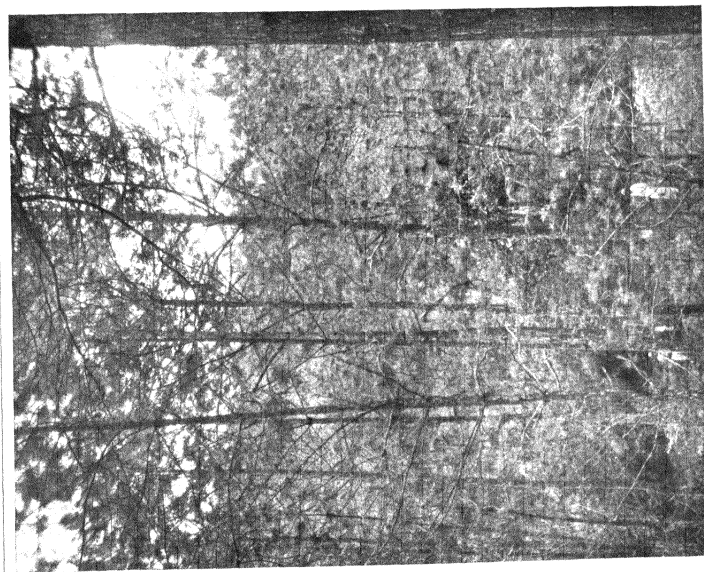
Abietic acid is soluble in a number of the common organic solvents.

There is considerable variation in the figures representing the specific rotation of abietic acid in different solvents.

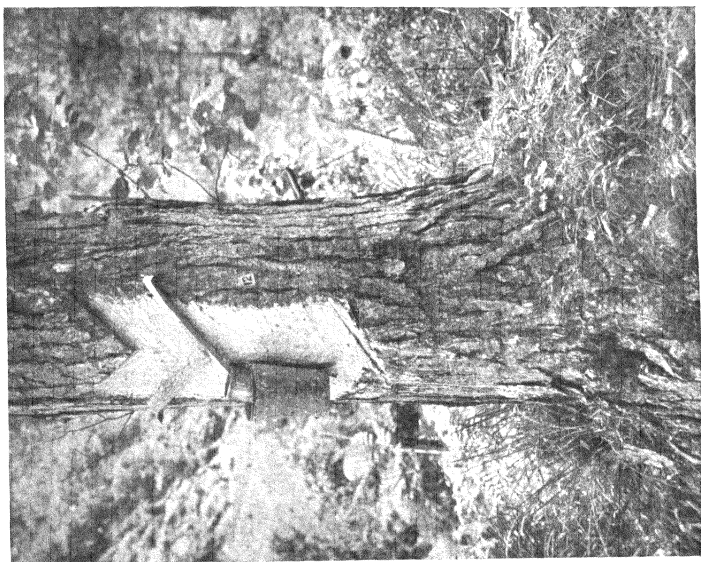
ILLUSTRATION

PLATE 1

- FIG. 1. Benguet pine forest.
2. Tapping a pine tree.



1



2

PLATE 1.

GEOLOGICAL RECONNAISSANCE OF NORTHWESTERN CAPIZ PROVINCE, PANAY, PHILIPPINE ISLANDS

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TEN PLATES

INTRODUCTION

A geological reconnaissance was made of the northwestern part of Capiz Province, Panay, in November, 1929, to study the possibilities of artesian-well drilling in that region, but as this was incidental to the study of the geological structure, the writer proceeded to make a formal geological reconnaissance with the double object of making recommendations to the Bureau of Public Works regarding the drilling of artesian wells and furnishing the Bureau of Science with a geological study of a part of the complex island of Panay.

The field work consisted in the examination of natural outcrops along the roads, trails, and shallow creeks and of the cuts along the newly built provincial roads. All data were controlled by compass and pace traverses, except in a few places where this procedure was interfered with by heavy rain. The Bureau of Forestry map was used as a base upon which our traverses were adjusted and tied to known points. The courses of a few small streams had to be revised, but outside of these minor discrepancies the base map was taken without alteration.

When the field work was carried out, from November 7 to December 10, the prevailing wind was the northeast, which brought great precipitation. This, according to the residents, usually continues until February. Due to this unfavorable weather the control of some of the data was not as accurate as the writer desired. However, this did not seriously affect the geological interpretation of the structures of the area.

LOCATION AND EXTENT OF AREA

The area covered by this reconnaissance is in the northwestern part of Capiz and extends from Campo Verde on the northwest to New Washington on the southeast and from the coast on the

¹ Resigned March 17, 1930.

northeast to the mountain front on the southwest. It is a strip of land, from 5 to 20 kilometers in width, bordering the coast for a distance of about 30 kilometers. It is approximately 200 square kilometers in extent and comprises the municipalities of Banga, Calivo, Makato, Malinao, and New Washington.

CULTURE

Calivo is the most important of these towns as it is located at the intersection of two important trade routes; namely, Aklan River and the provincial road. New Washington is next in importance; it is the port for Calivo and the distribution center of the communities bordering Banga Bay. The other towns are small, each containing two to three thousand inhabitants, with numerous smaller settlements scattered among them. The important industries are planting rice, hemp, and coconuts and, to a limited extent, cattle raising.

In none of these towns is there a water-supply system. The well-to-do collect rain water for drinking purposes, and some of them possess shallow incased wells from which water is pumped for domestic use. Some of the people living in the mountains who are favorably located get their water from springs, but the great majority depend on open surface wells. It is needless to point out here the hygienic dangers of this source of water supply. During my trip through this area, the rain was heavy and the contamination of the surface wells by surface water was at its maximum; consequently, dysentery and typhoid fever took a heavy toll from the student population of Calivo, not to mention the neighboring towns.

ACCESSIBILITY AND TRANSPORTATION

This area is accessible from Manila by several small inter-island steamships that call at New Washington every other day and occasionally in Ibahay. It usually takes two days to make this voyage, including two or three stops along the way. From the southern islands it may be reached via Iloilo, from which point one can go to Capiz, either directly by automobile or by train, and thence by steamer to New Washington. Most of the travelers prefer the latter way, which is less strenuous.

The principal routes of travel are the automobile roads, Aklan River, and Banga Bay, part of which is included in the accompanying map and located to the southeast of New Washington. The main trunk of the provincial road starts 2 kilometers north of Balete and passes through Banga, Calivo, Numancia, Makato, Tangalan, and Ibajay; from the last place it continues to Iloilo,

following the western coast of Antique Province. Two branches ramify from Calivo, a short one going northeastward to Busuang on the coast, and a longer one southeast to New Washington. From Numancia on the west side of Aklan River a branch goes southward via Lezo to Malinao. From Banga another branch goes southwest to Sigkay; from here it is projected southward to Iloilo along the valley of Aklan River. The road to Balete is part of the project to link Calivo with Capiz, the capital of the province. The barrios and settlements are connected by a network of trails, some of which are open enough for saddle animals, which, however, are not available.

Aklan River is wide and has a shifting sand bottom and a swift current, which make navigation unsafe. Only rafts and canoes moved with poles ply along this river as far as Libacao, 15 kilometers south of Rosario. Despite this handicap, however, more products are transported on this river than on the automobile roads parallel to it.

Banga Bay is navigable by canoes and shallow-draft boats. Its affluents, the Cailojan, Jal-o, and other rivers, are also navigable for short distances inland.

SURFACE FEATURES

TOPOGRAPHY

Other geologists who have visited Panay recognize two cordilleras on this island; one running north and south near and parallel to the western coast, the other branching from the middle of the first and running to the northeast corner of the island. The latter is not considered a cordillera in the strict sense, but this detail has no particular bearing on the present discussion.

The area under consideration is located on the eastern side of the north end of the first cordillera, or cordillera proper. In order to make its outlay clearly comprehensible it may be conveniently divided into three zones; the lowlands, the foothills, and the mountain front.

The lowlands occupy an area from 1 to 4 kilometers wide bordering the coast. It is made up of the deltas of the Makato, Aklan, Cailojan, and other less-important rivers; the sandbars between them; the swamps or the more or less completely filled estuaries behind the sandbars; and the alluvial plain immediately behind the swamps. The shore line is formed by the deltas and sand bars, except where Sigat and Apga Points project cliffs of sedimentary and igneous rocks.

The foothills of the intermediate topography form a wedge-shaped area pointing northwest to Sigat Point. They consist of sedimentary elevations ranging in type from sharp ridges adjacent to the mountain front to low smoothly rolling hills towards the lowlands. The highest elevation is that of Lumati Hill, which is 120 meters, and the maximum relief is about 75 meters. Except those next to the mountain front, the hills are separated by flat-bottomed valleys which form natural rice paddies and over these the creeks often spread in the form of washes instead of cutting narrow channels. In order to control the flow and distribution of water the farmers have built dirt dikes across these valleys, which become spotted with numerous small lagoons during the rainy season.

The mountain front is the eastern edge of the cordillera proper. It is marked by cliffs and steep mountain sides forming a natural and a strongly pronounced boundary between the sedimentary hills of the intermediate topography and the cordillera proper. The mountain front and the cordillera proper consist of igneous rocks, which form the backbone of Panay Island.

Some specially noteworthy features in the intermediate topography are the isolated prominences; namely, Tigayon, Malinao, and Mandoyog Hills. Tigayon Hill is located on the east bank of Aklan River, 1.5 kilometers northwest of Tigayon settlement. It is 20 meters high and 50 meters in diameter with a shape and an isolation that suggest an ancient burial mound. In fact, however, it is a solid block of massive limestone surrounded by quaternary alluvium. On the east side of the hill is a cave on the ground level, about the size of an ordinary room. Mandoyog Hill is located immediately south of Banga, and Malinao Hill is northeast of Malinao. They are cone-shaped and a little over 100 meters high. They are not entirely isolated but stand out sharply in contrast with the long and narrow little elevations that branch off from them. The branch from Malinao Hill extends northeast to about 1 kilometer beyond Lezo, and the branch from Mandoyog extends in the same direction and terminates at Magobinlod Hill. Unlike the other hills of the intermediate topography, Malinao and Mandoyog Hills consist of igneous rocks, mostly andesite.

DRAINAGE

The drainage system here is composed of Aklan, Tangalan, Makato, Cailojan, and Jal-o Rivers. The Aklan is the largest and longest of these. It rises from far in the interior of the

island, in the conjunction of the main cordillera and its eastern branch. The general course of this river is north, but on reaching the intermediate topography at Malinao the low and narrow elevation, already described above extending from Malinao to Lezo, has shifted it to the northeast. Beyond the end of the narrow elevation Aklan River resumes its original northward course and proceeds meanderingly to the sea.

Aklan River has numerous tributaries, most of which come from the cordillera to the west. The first one south from the mouth is Mahabang Tubig, which rises from the igneous cordillera. Above San Roque its course is controlled by the jointing of the igneous rocks, while below it flows northeast following the general slope of the country for about 2 kilometers and then bends to the southeast to empty at right angles into Aklan River. This sharp bend is suggestive of a fault of a southeast strike passing through Malinao and controlling the lower course of Mahabang Sapa.

Next in size to the Aklan is Tangalan River. It rises from the igneous wilderness west of the mountain front and follows a northerly course, probably along a sedimentary-igneous contact up to Panayacan. Here it turns abruptly north 70° east, following the strike of a fault of the same direction. This river is navigable by canoes as far as Panayacan.

Makato River has two main branches, one passing by Agbagogo and the other by Libang. Both of them rise from the mountain front, the Libang branch interning farther up the mountain than the Agbagogo branch. They have sinuous northeasterly courses following the general slope of the country for a short distance beyond Agbagogo and Cayanguan, and thence turn northward to join beyond Makato. Farther down, the river divides into two distributaries, one flowing northeast to Alibugan River and the other northwest, which unite again before emptying into the sea. The northwest distributary is connected with the swampy Dungon River, which is also a common distributary of Makato and Tangalan Rivers.

Cailojan and Jal-o Rivers, rise from the hills west of the Balete Road. They have a general northeasterly course and split into various anastomosing distributaries before emptying into Banga Bay.

Banga Bay is separated from the sea by sand bars. There is no doubt that this shallow body of water will ultimately be silted up with sediments from the various affluent rivers and will form an alluvial plain in the same manner as the alluvial plains east

of the foothills have been built. This process of refilling is going on also in the swampy area between Makato and Tangalan.

VEGETATION

Three types of vegetation may be recognized in this area; namely, the mangrove, the grass, and the forest.

The mangrove thrives in the swamps behind the sand bars, along the margin of Banga Bay, and on the banks near the mouths of the rivers within the reach of salt water.

The grass thrives in the lowlands and on the sedimentary hills of the intermediate topography, while the forests are generally found in the igneous country. This distribution of the grass and the forest vegetation does not correspond naturally to the nature of the soil or the underlying formations but to human activity and indirectly to the topography. The sedimentary area of the intermediate topography, which is easily accessible, has been cleared of forests by transitory farmers, who have thus transformed the country into vast cogon-covered patches. On the other hand the igneous country, which is severely broken and unarable, especially the mountain front, has not been subjected to this devastating process and its virgin forest has remained almost intact. The result is a very pronounced change of vegetation corresponding apparently to the change in the nature of the underlying rock formation. This does not hold true always, however, since farther in the interior there are patches of grassland on igneous formations where the mountain people, like their brethren along the coast, resort to the *cañgin* system of farming. Likewise, some very steep sedimentary hills west of Balete are also covered with forest.

The conglomerate hills have a peculiar way of responding to the growth of the grass. It is usually scanty and arranged noticeably in rows following the stratification of the beds. This is nicely illustrated in the hills west of Pudiot and north of Tandog.

GEOLOGY

STRATIGRAPHY

The formations that have been found in this area are tabulated and provisionally classified below. For comparison we have included the stratigraphic column of central Panay by A. D. Alvir,¹ who made a geological study of that area in the summer of 1927. We are also adopting his tentative stratigraphic classifi-

¹ Philip. Journ. Sci. 42 (1930) 443.

cation in order to minimize confusion, in as much as we have not found enough fossils to determine the exact geological age of the formations.

TABLE 1.—*Age, formation, and composition of northwestern Capiz and central Panay.*

Northwestern Capiz.			Central Panay.	
Age.	Formation.	Composition.	Formation.	Composition.
Quaternary-----	Alluvium-----	-----	Alluvium-----	30 meters.
	Not present-----	-----	Guadalupe tuff.	Tuff, tuffaceous sandstones, tuffaceous shales; 100 meters.
Tertiary {	Pliocene-----	-----		
	Not present-----	-----	Malumbang limestones.	Coral reefs; 150 meters.
	Miocene-----	-----	Lavas and Mount Panning Raon intrusives.	
	Malinao and Mandayog andesites.	-----	Badbaran formation.	Shales, sandstones, limestones; 700 to 800 meters.
	Makato formation.	Sandstones, shales; 500 meters.	Binangonan limestones.	Limestones, shales, sandstones.
Oligocene-----	Tigayon limestones.	Limestones, sandstones; 150 meters.		
	Campo Verde conglomerates	Conglomerates, sandstones, lignite; 175 meters.	Coal measures.	Sandstones, shales, lignite; conglomerates; 270 meters.
Pretertiary-----	Gabbro, serpentines.	-----	Igneous and metamorphics.	

THE PRETERTIARY IGNEOUS AND METAMORPHIC ROCKS

The pretertiary igneous and metamorphic rocks are the most extensively distributed rocks in this area since they form the mountain front and the bulk of the mountains of the cordillera proper. They show evidence of frequent faulting and pronounced folding and fracturing, especially along the contact with the sedimentary beds. The igneous consist of gray, medium-grained, and holocrystalline gabbro intruded by thin sheets or dikes of the same rock of lighter color and coarser texture, and also of white and dense quartz and anorthosite (samples 22, 23, and 24). Diorite phases are encountered in a few places (sample 60).

The metamorphic rocks are serpentine and schists. The serpentine is dark green, dense, and in places highly kaolinized. In a manner parallel to that of the gabbro, the serpentine is intruded with thin sheets or dikes of the same composition but of a lighter color and a coarser texture (sample 11). Some of the dikes consist of nodules of serpentine embedded in a ground mass of kaolin. The serpentine is found mostly along the mountain front in contact with the conglomerates.

The schists are essentially chlorite, green in color and altering to clay. They are associated with the serpentine along the zone of faulting in the igneous area in the vicinity of Rosario.

The analyses of a few of the specimens by Leopoldo F. Abad, of the Bureau of Science, are included at the end of this report.

THE CHERT FLOATS

Fragments or floats of chert were found 2 kilometers south of Sigkay and along the creeks southwest of Rosario. They are dense and red, similar to those found elsewhere in the Philippines and presumed to be of the Jurassic period. We have not been able to find the source and associations of the chert floats, so their age does not give us a clue to the determination of the ages of the other rocks.

THE CAMPO VERDE CONGLOMERATES (COAL MEASURES)

The Campo Verde conglomerates are associated with sandstones, the conglomerates occupying the lowest place and lying directly on the basal igneous. The conglomerate beds are massive, showing only hints of stratification in isolated outcrops. They consist of gabbro and serpentine pebbles, ranging from 2 to 15 centimeters in diameter, cemented with a matrix of brown and coarse sand or green to dark green weathered serpentine. The finer pebbles are well rounded and are found in the upper beds, while the larger ones are semiangular and found in the lower beds. Occasionally, unusually large and angular pebbles are scattered haphazardly in the more massive beds in which stratification is absent.

It is not easy to locate exactly the contact between the igneous and the overlying conglomerate beds, as these grade down to a breccia consisting of recemented fragments of the base rock, then to severely fractured and refilled igneous, and finally to solid igneous. This gradual transition can be observed near kilometer 11 of the Campo Verde Road cut and at Jawili Falls, northwest of Tangalan.

The associated sandstones are brown to gray in color, from medium to coarse in texture, and not well consolidated. They are usually massive, but sometimes very thin, barely enough to mark the bedding planes of the conglomerate beds. Some of the thick beds contain lenses of poorly consolidated conglomerates of 1-centimeter pebbles. Others are shaly and contain fragments of carbonized wood and plant remains of undiscernible features. These carbonized particles are more noticeable in the outcrops in the vicinity of Balete than in the northern area. In Cailojan Creek, west of Balete Road, the sandstone beds that are being quarried for road ballast are so black with those carbonized fragments that they have been mistaken for coal by some people. These black sandstones, however, turn gray on drying, which happened with the samples collected by the writer. The Campo Verde formation is about 175 meters thick.

THE TIGAYON LIMESTONES (BINANGONAN)

The Tigayon limestones are not uniformly distributed and developed. While they are massive and almost without association in Tigayon Hill, they are thinly bedded and intercalated with sandstones in Cailojan Creek. They could not be found northwest of Aklan River, although the formations directly underlying and overlying them are widely exposed.

The limestone members are white to pale pink and gray in color, dense to granular in texture, and contain unidentified Foraminifera. The granular variety contains inclusions of igneous grains. In some beds the limestone forms the matrix of a conglomerate of igneous pebbles of red, brown, and gray color and about 0.5 centimeter in diameter. The sandstone members are well and thinly bedded, ranging in thickness from 1 to 10 centimeters. They are of different shades of gray and brown, pure to shaly, finely grained, and from soft to hard.

Except in Tigayon Hill, the Tigayon formation does not feature prominently in the topography, its maximum thickness being only about 150 meters.

THE MAKATO FORMATION (BADBARAN)

Of all the tertiary sedimentary formations the Makato is the most widely distributed; it forms the hills of the intermediate topography. This formation consists of intercalations of thin and well-stratified sandstones and shales, typical exposures of which can be seen in the road cut near Makato and in Apga Point, north of Tangalan. The sandstones are fine grained,

hard, light gray, and sometimes with a faint banding parallel to the plane of stratification (sample 48). The shale members are pure to sandy, soft, and brown to gray, which weathers to yellow. In some places thin and sandy laminae containing Foraminifera are found in the bedding planes of the shales (sample 33). Good exposures of shales with a few intercalated sandstones are found east of Libang.

This formation has a different thickness according to the section in which it is calculated, but about 500 meters may be taken as a conservative average. The exaggerated thickness obtained in Section B may have been due to a series of small faults which have caused the repetition of the same formation east of Libang.

THE MALINAO AND MANDUYOG ANDESITES (MOUNT PANING RAON INTRUSIVES)

The andesites occur as elongated intrusions of a northeast direction on either side of Aklan River and as protuberant cone-like prominences in Malinao and Mandoyog. These intrusions have pushed up and exposed the basal conglomerates of the Campo Verde formation which are naturally older. Hence the andesite intrusions have been classified under the Miocene age, although they could be of the later stage of the Oligocene period.

The andesite varies slightly in character in different localities. One type (sample 63) is dark to light gray in color, granular in texture, and contains macrocrystals of hypersthene, vesicules, and vugs with white crystals of zeolite. This type is found at the top of Magabinlod Hill, northeast of Banga. The other type is light gray, fine grained, and hypocrySTALLINE. It is found in Mandoyog Hill immediately south of Banga, in Lezo and Malinao Hills, and on the slopes of Magabinlod Hill. These two types are evidently facies of the same intrusion.

THE QUATERNARY ALLUVIUM

Under the Quaternary alluvium we have grouped together the Pleistocene and the recent sediments as they cannot be differentiated in the field. Moreover, their mutual relation has no particular bearing on the underlying structures.

These sediments consist of sand along the bars, mud and silt in the deltas, sandy and clayey loams in the flood plains, gravel and sand along the river banks, and laterite. The clayey loam of the flood plains and the river valleys is very extensive. This and the mud and silt of the deltas are of high economic importance as they cover the most fertile rice lands. On the other hand, the sand bars are thickly planted with coco trees. The

laterite is of local occurrence, and is found on the eastern slopes of the hills west of Pudiot. It consists of clay with a high percentage of red and orange limonite. Banks or bluffs of this formation are conspicuous from the automobile road near Pudiot.

CORRELATION

Since fossils are scarce we are using the physical characters of the formations as the only criteria for correlating them and for comparing our columnar section with that of central Panay. Since these sections belong to the same geological unit and the distances separating them are small, the use of the physical characters alone as criteria for correlating them is quite satisfactory.

It will be noticed that in our area we found no formation that can be correlated with the Malumbang limestone, which consists of shales and coral reefs, and the Guadalupe tuffs, all of which form prominent features in the topography of central Panay. We have andesite intrusives, which intersect the Oligocene conglomerates and correspond to the Paning Raon intrusives in central Panay, but no lava. The Badbaran formation of central Panay corresponds to our Makato formation in physical characters, except that our Makato formation has no limestone intercalations; and while the shales and sandstones are equally developed in central Panay, the sandstones predominate in the Makato formation. The Binangonan formation of central Panay corresponds to our Tigayon formation, both containing limestone as well as conglomerates; the former, however, is a great deal thicker than the latter and is associated with shales instead of shaly sandstones. Our Campo Verde conglomerates correspond to the Coal Measures of central Panay in every respect, except that the former are not intercalated with limestones.

From the above comparisons it appears that there is a lateral decrease in the development of sedimentation from central Panay towards the north. This is especially true of the Pliocene formations, which are entirely missing in our area. Even here the lateral diminution of deposition can be detected in the distribution of the Tigayon limestone. It is about 270 meters in central Panay, about 150 meters in Balete, 25 in Tigayon, and disappears altogether northwest of Aklan River. The limestone intercalations of the Coal Measures of central Panay likewise disappear from the corresponding Campo Verde formation of our area.

There is also a lateral change in facies, the shales in our area being more sandy than the corresponding formations of central

Panay. There is a hint, therefore, that the source of sedimentation is from the north, or that the sedimentation here occurred in a shallower sea than that in which it took place in central Panay.

DEFORMATION STRUCTURES

Several deformation structures were found in this area, the most important of which are described in the following paragraphs:

THE TANGALAN ANTICLINE

The Tangalan anticline is about 8 kilometers long and 2 to 3 kilometers wide, with an obtuse crest dipping about 35° on either side. It passes through Agpa Point and runs southward to Tangalan and then gradually turns to the east towards Ali-bangon. Beyond this place the anticline is lost in the low lands north of Numancia, but the strikes of the outcrops near Makato suggest that it continues towards Calivo. The crest and the flanks are all in the Makato formation; the sandstones predominate on the crest and the shales on the flanks.

THE TANGALAN FAULT

The Tangalan fault passes through Panayacan and along the lower course of Tangalan River, which it controls. It is 4 kilometers long and has a strike of approximately north 80° east. Its apparent lateral displacement is westward on the south side of the fault, being probably the component of an actual downward displacement.

Two features have been produced by this fault; one is the bend of Tangalan River at Panayacan at almost right angles, and the other is the discontinuity of the topography as well as of the formations across Tangalan River. It can be noticed that the topography and the formations have been pushed westward on the south side of Tangalan River.

THE LIBANG SYNCLINE

The Libang syncline is 6 kilometers long and 3 kilometers wide. It is shallow, and its axis has a sigmoid shape with a general north and south trend. It shows remarkably well in the topography since erosion has not advanced far enough to obliterate the structural trough and the partly rounded hogbacks on the flanks. Its north end abuts against the frontal gabbro, and its southern end terminates in San Roque. It is cut by a large fault on the west flank, which will be described presently, and by a minor one (probably by several others un-

observed) on the east flank. This syncline is traversed by the Libang branch of Makato River.

THE AGBAGOGO FAULT CONTACT

West of Agbagogo there is a fault running approximately north and south along the igneous-sedimentary contact. This fault is evidenced by cliffs and various waterfalls at the heads of the two branches of Agbagogo River. The cliffs are very conspicuous at a distance and can be traced as far north as Tangalan River and as far south as Makato Falls. At this point the fault is no longer along the contact but in the mass of the basal igneous rocks. The displacement is downward on the east side of the fault and maximum towards the south. This difference in displacement explains the difference of the amount of conglomerate beds exposed in different places along the fault. They are well exposed west of Pudiot and missing west of Libang.

THE LUMATI ANTICLINE

The Lumati anticline is located 2.5 kilometers west of Balete. Its axis has a north 10° west direction and passes through Lumati Hill, which is the highest in the vicinity. On the obtuse crest are conglomerates and sandstones of the Campo Verde formation, and on the east flank are Badbaran limestones and sandstones. The east flank terminates in a narrow and shallow syncline; the west flank is not well defined. This anticline may extend farther north than indicated on the map, as the topography suggests, but the writer was unable to examine this end and the west flank on account of unfavorable weather.

The syncline west of Rosario was not actually located in the field, but it is a necessary inference from the adjoining structures on either side. It has a north and south axis, which probably bends to the northwest towards Venturanza.

THE VENTURANZA ANTICLINE

This anticline is 1.5 kilometers long and has a northeast and southwest axis. The crest is dissected by Cailojan River where massive conglomerates of the Campo Verde formation are exposed and dip more steeply on the northwest side than on the opposite side. The northwest flank of this anticline is in Makato shale and sandstones and terminates in a parallel syncline of equal length, while the southeast flank is only 0.5 kilometer wide. Beyond this distance the beds reverse their attitude to form the west flank of a probable anticline lying to the east. The short syncline west of the Venturanza anticline is probably the extension of the one lying east of Rosario.

THE MAHABANG SAPA FAULT

The Mahabang Sapa fault is about 4 kilometers long; it strikes approximately to the northwest and passes through the town of Malinao and along Mahabang Sapa. The lateral displacement is southeast on the northeast side of the fault, as the conglomerate outcrops indicate. This fault is the controlling factor of the lower course of Mahabang Sapa, which it diverted at 2 kilometers northeast of San Roque and deflected in its course from northeast to southeast.

TECTONIC LINES

It will be noticed that except for the Tangalan fault, the Malinao fault, and the Tangalan anticline the deformation structures described above are more or less parallel to two directions; one north 20° west, which is the trend of the gabbro intrusion forming the bulk of the Cordillera proper; and the other northeast, the trend of the andesite intrusion on either side of Aklan River. We may, therefore, consider these two as the major tectonic lines here, the north- 20° -west direction being more prevalent than the other.

The direction of the axis of the Tangalan anticline is not necessarily due to a third direction of tectonic force, but is probably the resultant of the combination of the two major ones. The direction of the Malinao fault, while not in accord with either of the major directions, does not vary radically from the directions of the adjoining anticline and fault to the north. The Tangalan fault remains then the only deformation structure whose direction digresses from that of the two major tectonic lines, and its cause must be considered local.

ECONOMIC GEOLOGY

The writer did not penetrate far enough into the igneous country to give an authoritative account of the mineral possibilities in this territory, but what is certain is that the igneous outcrops, along the rivers and creeks, and the igneous boulders show no mineralization. Reports have been received of the existence of gold in the interior southwest of Malinao, but they are of a legendary color and it is hard to say just how much credit should be given to them.

The reported coal south of Daja, in a place called Pinacasunagan, was found to be black shale; and that 2 kilometers northwest of Balete was found to be black sandstone; the color of both formations is due to minute fragments of carbonized plant remains. Coal was reported to have been found south of Balete,

but this place was not reached by the writer. It is not unlikely that coal might be found here, because the Campo Verde formation, which is coal-bearing elsewhere in the Philippines, is present.

Of actual economic importance are the limestones, sandstones, and gravel, the last two being actually utilized for building purposes. The gravel along the Aklan and other rivers furnishes a cheap material for concrete mixture and road ballast. The black sandstones that are being quarried in the upper Cailojan Creek, previously reported as coal, are also used for road ballast. The limestones of Tigayon Hill may be used for the manufacture of a limited amount of lime.

UNDERGROUND-WATER RESERVOIR

In this area there are two kinds of rocks that may serve as water reservoirs; namely, the conglomerates and the sandstones of the Campo Verde formation. They are both porous and located favorably for intake west of Pudiot, in Lumati Hill, and also, although not extensively, along the Malinao-Lezo hills. Outcrops of these beds have been observed actually oozing water along the Balete Road and in some hills north of Malinao. There are also shaly sandstone beds on the top of the Campo Verde formations that may act as cap rock over the reservoir. One possible drawback, however, is their location at the bottom of the sedimentary formations, which may be too deep to be reached by economic drilling in the very places where artesian wells are needed.

The Tigayon limestone and the sandstones of the Makato formation are not likely to contain water. The limestone beds are not uniformly distributed on the former, and they are not porous or cavernous on the latter. The Makato sandstone beds, on the other hand, are thinly bedded and too dense to contain water.

POSSIBLE SOURCE OF SURFACE-WATER SUPPLY

There are two falls here that may be used as sources of water supply; namely, the Jawili and the Makato Falls.

Jawili Falls is located 0.5 kilometer beyond the head of the Hawili estuary, 3 kilometers northwest of Tangalan. The falls occur over Campo Verde conglomerates and are fed by a perennial creek. At the foot of the falls there are large pot holes or solution holes, which are being used as swimming pools by excursionists that come from the neighboring towns. The head of the falls is about 15 meters high and the water, which

comes from an igneous country, is clear and perhaps is sufficient to supply the town of Tangalan, but not more. The water could be piped to Tangalan easily without going over any hill.

Makato Falls is located over a fault in the igneous formation 2 kilometers southwest of Libang. The head of the falls has an elevation of about 75 meters, and the drop is over 40 meters. The water comes from several small streams, which rise from the igneous country behind the mountain front and unite at a short distance behind the head of the falls. Here the stream has an average width of 2 meters, a depth of 25 centimeters, and a good flow, which insure a good volume of clear water. There is a narrow cañon of solid igneous rocks just behind the falls that would make an ideal dam site, from which the water could be piped over a moderately undulating country following the valley of the Makato River to the neighboring coastal towns of Makato, Calivo, and New Washington.

CONCLUSION AND RECOMMENDATION

CONDITIONS NECESSARY FOR AN ARTESIAN WELL

The object of an artesian well, as it is understood here, is to tap a pool of potable underground water, which may occur in pervious beds of sedimentary rocks or in fissures in igneous rocks. Since there is no accurate method of determining the occurrence of fissures deep in igneous rocks, much less their size, drilling for artesian wells in an igneous country is very uncertain. On the other hand, because of the tabular form of the sedimentary beds whose attitude can be measured accurately, the position and attitude of the reservoir rocks in the sedimentary areas can be calculated approximately, thereby making the scientific location of the artesian well possible. It is, therefore, only the study of the possibilities of artesian wells in the sedimentary area that will be treated here.

In order that the underground water pool in sedimentary rocks may be tapped with a well successfully, it must be confined in a pervious rock called the reservoir rock, lying between two impervious beds, usually of shale or clay. The underlying impervious bed is not always necessary, but there must be an overlying impervious bed or cap rock. Besides, the reservoir bed must be either inclined or folded in the form of a basin or syncline; and in the latter case it must be exposed on either or both flanks so that the water falling on it can accumulate in the basin, or syncline. There are other geologic structures that may give artesian flow, but they are not discussed here

because of their absence in the area studied. If the water in the reservoir is tapped with a well, it will rise to a height proportional to the pressure due to the head of the intake minus the frictional resistance that the reservoir bed offers to the flow of the water.

ARTESIAN-WELL POSSIBILITIES IN THIS AREA

There are good reservoir rocks in this area, as mentioned in a previous section, and they are folded into favorable structures for water accumulation. None of the important communities that need artesian wells is located within these structures, however.

Beginning from the north, Tangalan is located on the crest of the Tangalan anticline, Makato and Numancia are about 1.5 kilometers south of it, while Calivo lies on the crest of its probably eastward extension. It is easy enough to conjecture that the water in the trough of the synclines may rise to the crest of the adjoining anticlines periodically when there is great precipitation on the intake, but this migration of water along the reservoir beds is not certain in this area because of the intervening faults.

Lezo is located on an andesite intrusion, except its northwestern suburb which lies on the very intake of the syncline or trough to the west. Malinao is located on the northwestern flank of the Malinao andesite intrusion where the catchment area is limited; with the additional disadvantage that it is close to the Mahabang Sapa fault, which may intersect the reservoir beds. Banga is similarly located on the northwest flank of the Mandoyog intrusion, where again the conglomerate catchment area is very limited. Balete is located 2 kilometers east of the south end of a small syncline, a distance which places it outside of the trough. New Washington is 9 kilometers from the nearest, exposed, deformation structure, where the nature of the underlying structure is entirely conjectural. Therefore, drilling for structural underground reservoirs cannot be recommended for the above-mentioned communities.

However, these communities are located on or next to good quaternary alluvial deposits of gravel and sand, which are good reservoirs of subsurface water. In the absence of favorable deformation structure, these water-bearing alluvial deposits should be sought in drilling for subsurface wells. Malinao, Banga, Balete, and, possibly, Lezo are especially recommended as they are next to fresh-water streams, which can supply the subsurface

gravel reservoir. Exceptions are made of New Washington, Makato, and Numancia, which are located near sea level, where subsurface water will be contaminated with sea water. Drilling here would be equivalent to drilling in reclaimed land, like the New Luneta, Manila, where salt water certainly would be encountered.

There is a certain feature that must be considered with regard to Calivo. This town is located on the delta of Aklan River, and cases are known of successful artesian wells in similar locations in the Philippines. The water in such a location is tapped from the fresh underflow through buried gravel lenses that are fed from the upper courses of the streams. Considering the importance of Calivo, it is hereby recommended that a test be made on the possible underground gravel lenses.

Tangalan is similarly located. But here, between drilling wells and piping the water from Jawili Falls, the latter is easily the better choice, provided the town can afford it.

In conclusion, drilling for structural artesian wells in the important communities in this area is highly speculative, while drilling on the favorable structures is impractical because of their distance from the communities. Incased subsurface wells in the quaternary gravel are recommended, however, in the immediate vicinity of Lezo, Malinao, Banga, and Balete; and, though less strongly, in Calivo and Tangalan.

Artesian wells, lastly, should be considered only as a temporary measure; and surface sources, such as Makato and Jawili Falls, must ultimately be developed to insure a good and abundant supply of potable water to the coastal towns.

The following petrographic examinations of rocks collected in Capiz Province were made by Mr. Leopoldo F. Abad, mining engineer, Bureau of Science.

Field No. QAA 11.

Rock name, serpentine (from peridotite); collector, Q. A. Abadilla (1929); locality, Agsasawa Creek, Malinao.

Megascopic.—The sample is an altered, fine-grained, amorphouslike ultra-basic rock, intruded by a one-inch dike of a similarly altered, mottled with porphyritic-effect, less basic rock.

Microscopic.—Under the microscope the intruded rock has a mesh fabric showing an almost complete serpentinization of the original rock. A few grains of olivine remain unaltered. The dike is also almost completely altered, with the ferromagnesian

minerals changing into mesh-textured serpentine as that of the intruded rock embedded in amorphous kaolinite.

Minerals.—The intruded rock is chiefly serpentine with grains of chromite and magnetite, some chlorite, and a few grains of unaltered olivine. The dike contains serpentine, some peroxene minerals, olivine, bastite, magnetite, chromite, and kaolinite.

Remarks.—The dike is less basic, and appears to be a later injection of the same magma from which the peridotite was first differentiated. The embedding mass consists of kaolinite resulting from the alteration of the original feldspar. Therefore, it is probable that, with the accessory minerals found, the dike was originally an olivine-gabbro.

Field No. QAA 23.

Rock name, gabbro; collector, Q. A. Abadilla (1929); locality, San Roque Barrio, Malinao.

Megascopic.—The sample is a phanerocrystalline, dark gray, melanocratic, medium to coarse-grained rock.

Microscopic.—Under the microscope it has a seriate intersertal semiophitic fabric.

Minerals.—The essential mineral is labradorite. The accessory minerals consist of augite, diallage, and ilmenite. The secondary minerals are magnetite, bastite, rutile, limonite, and chalcedony (veinlet fillings).

Field No. QAA 60.

Rock name, quartz-diorite (altered); collector, Q. A. Abadilla (1929); locality, Venturanza-Sigkay Road, Banga.

Megascopic.—The sample consists of residual angular pebbles of a partly weathered, grayish white, medium-grained rock.

Microscopic.—Microscopically it is holocrystalline, inequigranular, hiatal with porphyritic effect. The phenocrysts are single and groups of anhedral and euhedral quartz, and some tabular feldspars. The original ferromagnesian minerals are not found, but have probably all changed into chlorite which are found in irregular shapes and almost invariably contain included or attached grains of magnetite. The groundmass is micrographic.

Minerals.—The essential minerals are quartz and feldspar of the andesine-oligoclase series. The secondary minerals are chlorite, few magnetite grains (some cubic), and kaolin.

Field No. QAA 62.

Rock name, augite-andesite; collector, Q. A. Abadilla (1929); locality, Mandyog Hill, Banga.

Megascopic.—The sample is a gray, vesicular, hypocrystalline rock. Some pores contain fillings of limonite and zeolites.

Microscopic.—Under the microscope the fabric is docrystalline, porphyritic dosemic. The phenocrysts consist of subhedral and euhedral tabular plagioclase crystals and euhedral pyroxene minerals in diverse arrangement. The pyroxenes invariably contain some attached grains of magnetite. Some plagioclase phenocrysts show zonal structure. The groundmass is felsophyric.

Minerals.—The essential mineral consists of plagioclase of the andesine-labradorite series. The accessories are augite, enstatite, and apatite. The secondary minerals are magnetite, urallite, bastite, and kaolin.

Field No. QAA 63.

Rock name, hypersthene-andesite-porphyry; collector, Q. A. Abadilla (1929); locality, Magabinlod Hills, Banga.

Megascopic.—The sample is light to dark green, vesicular, porphyritic with few megaphenocrysts of large, prominent, and well-developed crystals of orthorhombic pyroxene. Some vesicles are filled with secondary calcite and zeolites.

Microscopic.—Under the microscope the fabric is hypocrystalline porphyritic perpatitic. The phenocrysts consist of anhedral and subhedral tabular crystals of plagioclase in diverse arrangement, some euhedral pyroxene minerals and grains of magnetite. A few crystals of plagioclase show zonal structure under cross nichols. The groundmass is felsophyric and shows slight alteration.

Minerals.—The essential mineral consists of feldspar of the andesine-labradorite series. The accessories are hypersthene and augite. The secondary minerals are magnetite, limonite, and kaolin. The secondary calcite and zeolites are found in vesicles.

Remarks.—Some of the hypersthene crystals measure more than 10 millimeters in diameter.

ILLUSTRATIONS

PLATE 1

- FIG. 1. Sandstone beds at kilometer 98 of road west of Makato.
2. Subuk Mountain, the broken cone in the background. This mountain is made up of sandstones and massive conglomerates.
 3. Tigayon Hill, on the east bank of Aklan River 4 kilometers south of Calivo. This is an isolated hill of limestone. View from Parian Hill across Aklan River, 1.5 kilometers northeast from Lezo.

PLATE 2

- FIG. 1. Calimbahan River and Valley. The valley is characteristic in the tertiary sedimentaries; wide and U-shaped.
2. The outer fringes of the hills bordering the quaternary alluvium. Note the abrupt end of the hill on the left third of the picture, facing the coast, suggestive of wave cutting. In the foreground is the Capiz provincial road between Makato and Pudiot Barrio.
 3. Horizontal shale and sandstone beds, 2 kilometers northwest along the road from Balete. A normal fault of about 1 meter displacement shows on the left third of the picture.

PLATE 3

Looking down from above the head of Makato Falls. Note the narrow cañon. From this point to the foot of the falls there is a drop of about 60 meters.

PLATE 4

Makato Falls, 1 kilometer west of Libang. Drop of falls in sight is about 40 meters. This is the source of the proposed water supply for Calivo and neighboring towns.

PLATE 5

- FIG. 1. Panoramic view of western Capiz, taken from 1 kilometer north of Libang. The thickly wooded mountains to the left are igneous. The grass-covered hills are tertiary sedimentaries. The flats to the right bordering the coast are quaternary alluvium.
2. Panoramic view of western Capiz Province, taken 1 kilometer east of Subuk Mountain, looking to the east. The last mountain to the right in the background is igneous. The next mountain, which is conical in profile section, is made up of sandstones and shales. These are the lower strata of the tertiary sedimentaries which form the low hills farther west, or in the middle background. The flat area is made up of coastal plain, delta, and sand bars.

PLATE 6

- FIG. 1. Panoramic view of western Capiz Province, taken 2 kilometers north of San Roque, looking northward to the coast.

FIG. 2. Panoramic view of western Capiz, from Lumati Mountain. The hills in the foreground are tertiary sedimentaries and the flats in the background towards the coasts are quaternary alluvium. The village of Balete can be seen in the right third of the picture.

PLATE 7

- FIG. 1. Rock specimen QAA 11; natural size.
2. Section of rock specimen QAA 11; $\times 82$.

PLATE 8

- FIG. 1. Section of rock specimen QAA 23; $\times 82$.
2. Section of rock specimen QAA 62; $\times 82$.

PLATE 9

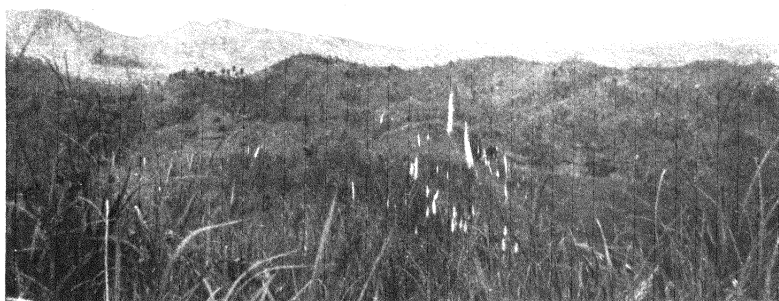
- FIG. 1. Rock specimen QAA 63; natural size.
2. Section of rock specimen QAA 63; $\times 82$.

PLATE 10

Geologic map of northwestern Capiz Province, Panay, comprising the municipalities of Banga, Calivo, Makato, Malinao, and New Washington.



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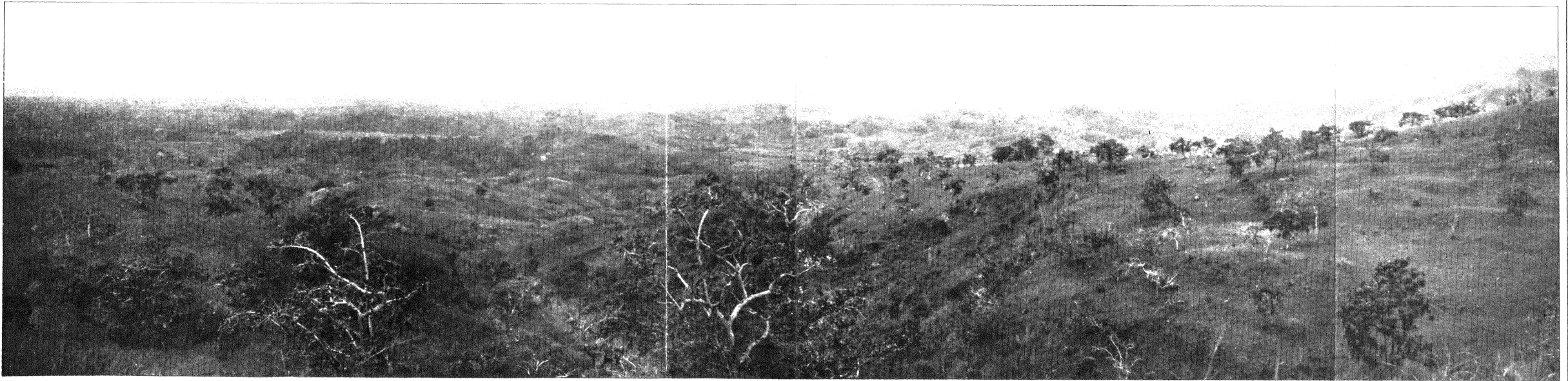
PLATE 3.



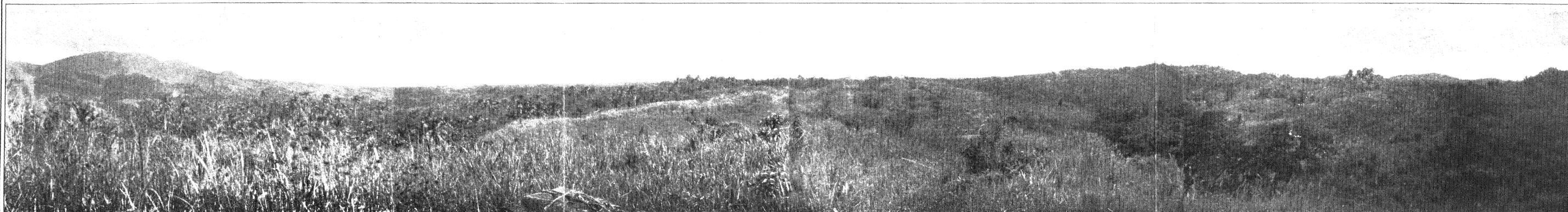
PLATE 4.



1



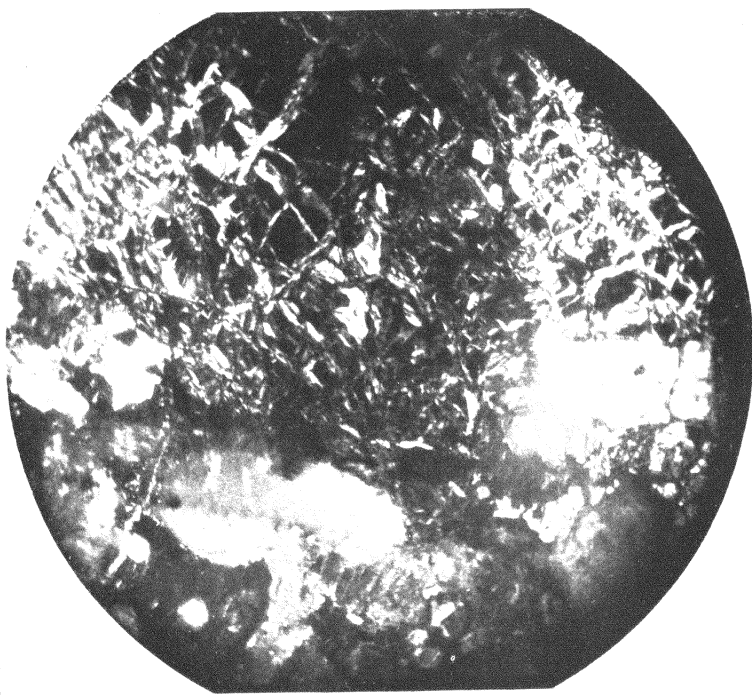
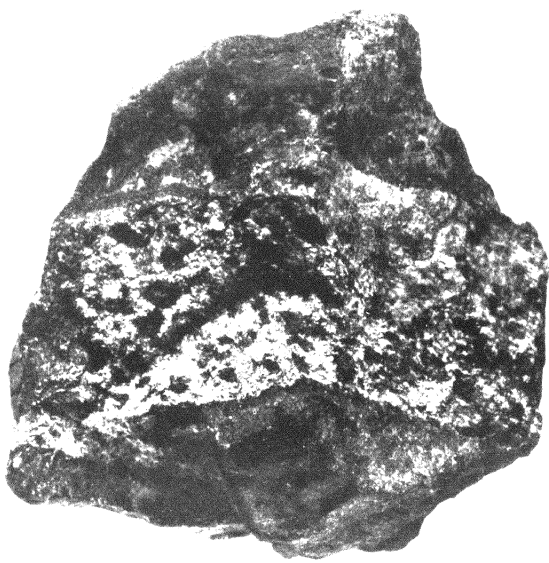
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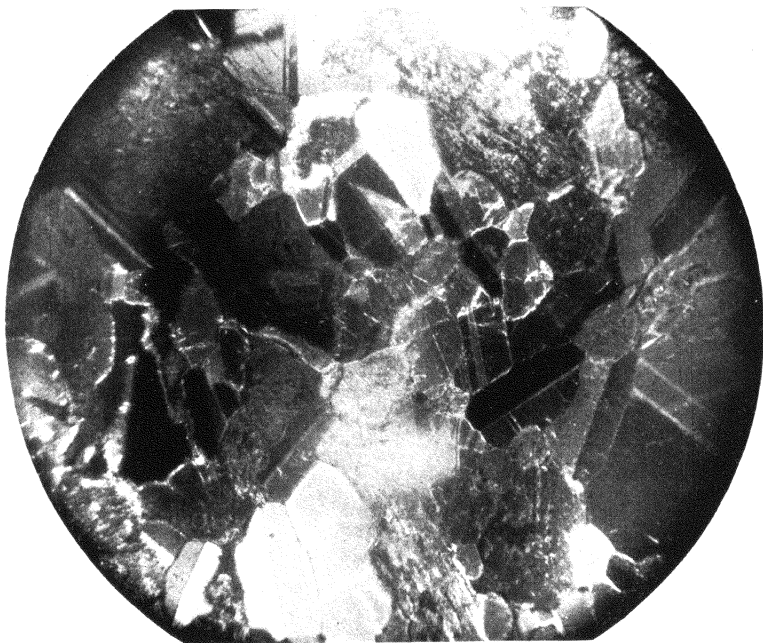


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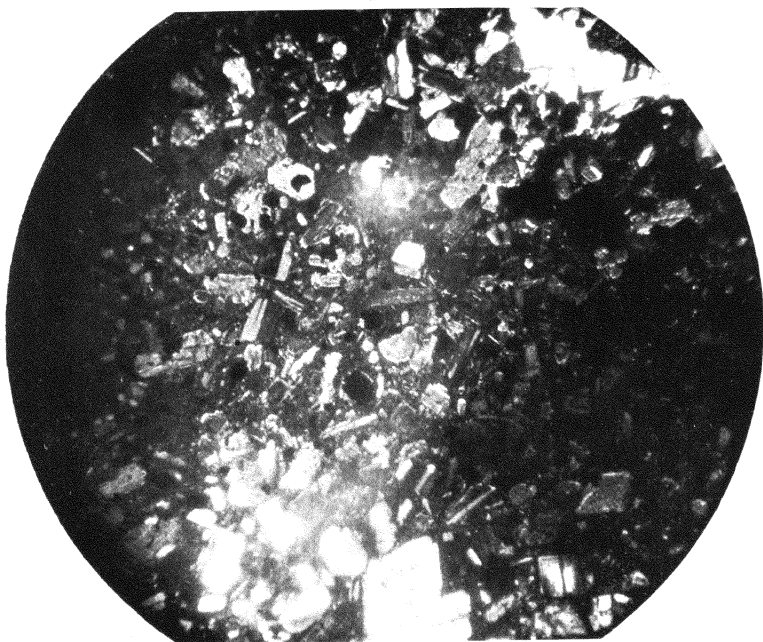


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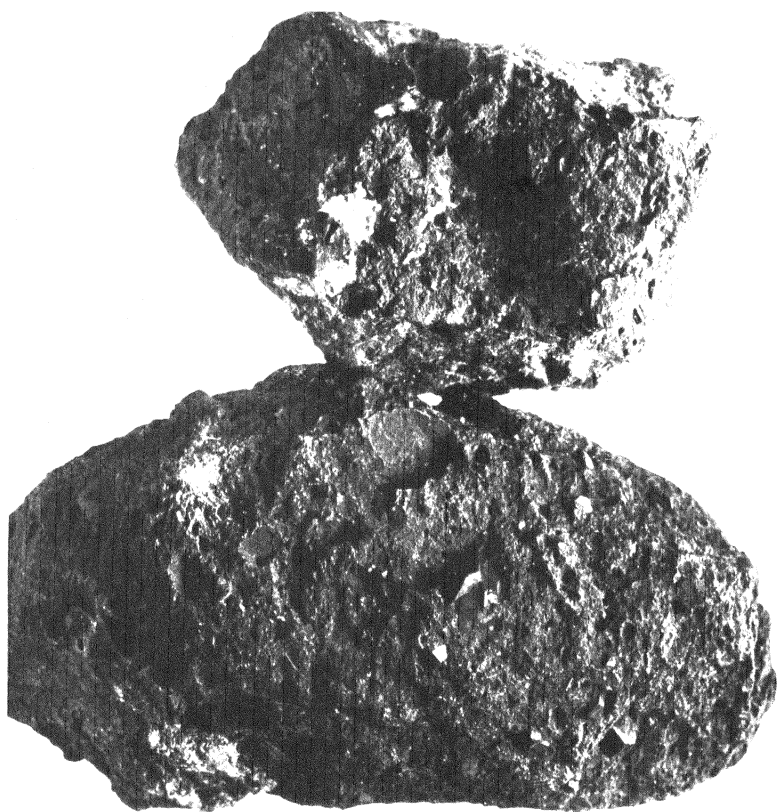




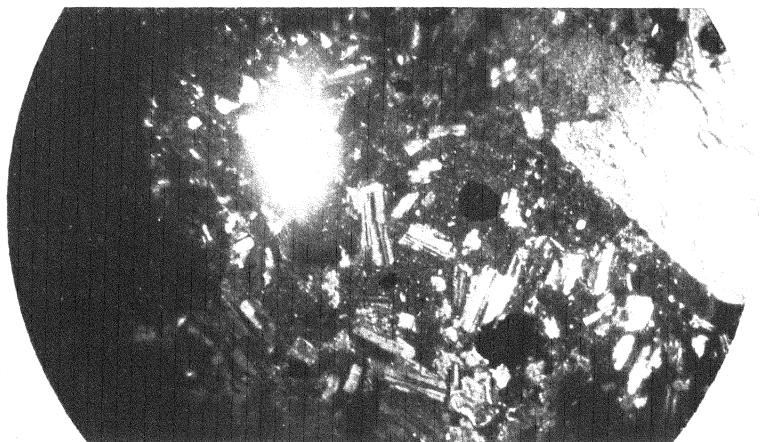
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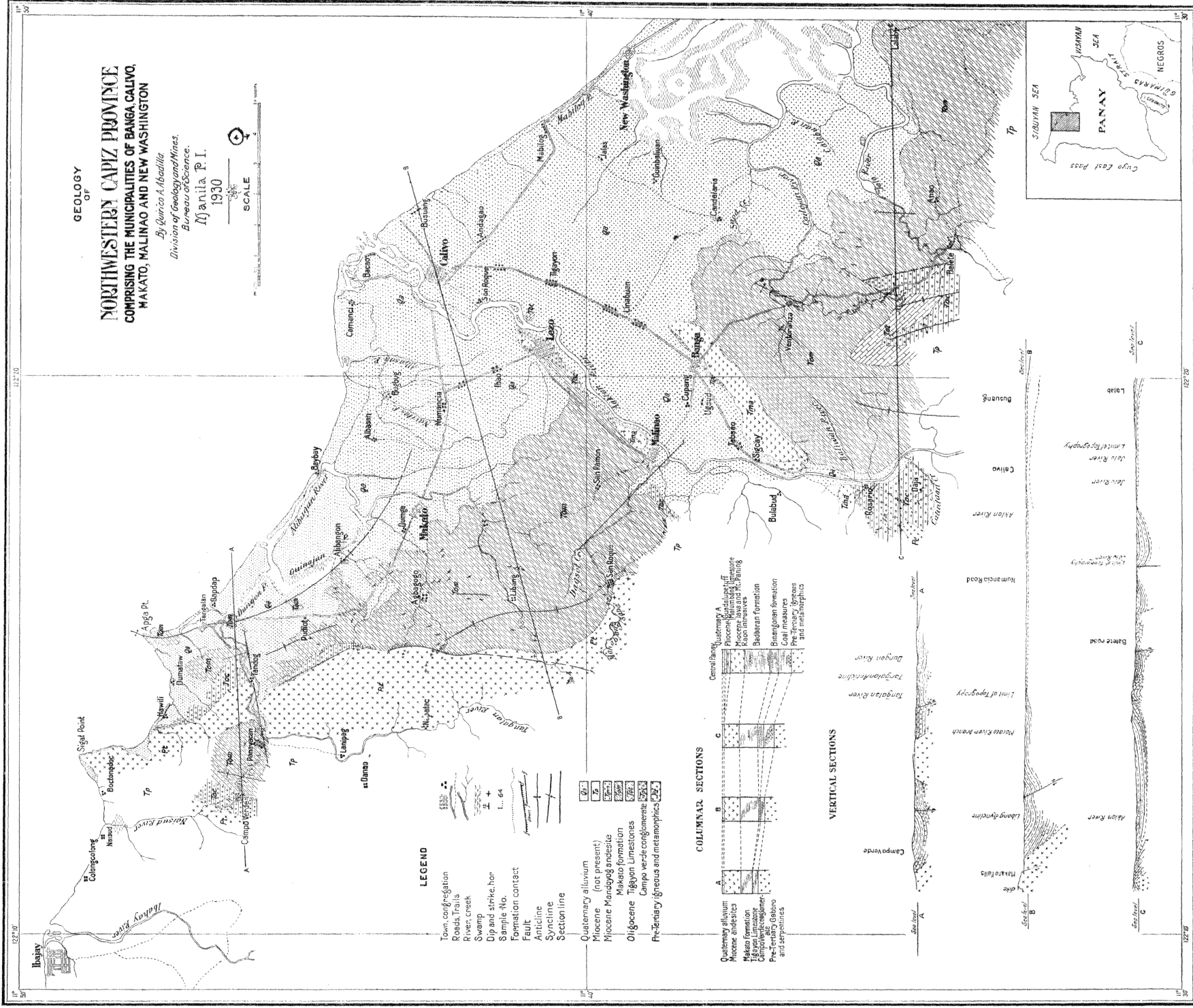


PLATE 10. NORTHWESTERN CAPIZ PROVINCE, PANAY.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM THE PHILIPPINES (DIPTERA), IX ¹

By CHARLES P. ALEXANDER

Of Amherst, Massachusetts

THREE PLATES

The crane flies discussed in the present report are chiefly from the La Lun Mountains, Davao district, Mindanao, Philippine Islands, where they were collected at altitudes of between 5,500 and 5,800 feet, by Mr. Charles F. Clagg. A few of the species described from Mindanao were also found to occur in Luzon, where they were taken by Messrs. McGregor and Rivera. I wish to thank the above gentlemen for their kind coöperation in this study of the tipulid fauna of the Philippines and for the privilege of retaining the types of the novelties described in my collection.

TIPULINÆ

SCAMBONEURA MINDANAOENSIS sp. nov. Plate 1, fig. 1; Plate 2, fig. 23.

General coloration yellow, the præscutum with three metallic black stripes; vertex with a dark median vitta; antennæ (male) relatively short; wings with the elements of the anterior cord in nearly transverse alignment; male hypopygium with the outer dististyle a long yellow rod that terminates in a blackened spinous point; appendage of ninth sternite a long slender orange rod.

Male.—Length, about 13 to 14 millimeters; wing, 12.5 to 15; antennæ, 3.

Female.—Length, about 16 millimeters; wing, 15.

Frontal prolongation of head orange yellow, with a narrow black dorsomedian line; nasus elongate, black; palpi obscure yellow, passing into black outwardly. Antennæ relatively short in both sexes; scape yellow; flagellum (male) black; (female) black, in cases with the incisures of the basal segments restrictedly yellow. Head obscure orange yellow to brownish yellow, with a conspicuous brown line on vertex, this narrower in female.

¹ Contribution from the entomological laboratory, Massachusetts Agricultural College.

Pronotum black, the broad central portion of the posterior notum yellow. Mesonotal præscutum yellow with three black stripes, with greenish reflections in male, more purplish in female; scutal lobes with the entire lobes similarly darkened; median region of scutum light yellow; scutellum darkened, light yellow at base; postnotal mediotergite light yellow, with darkening at both base and apex. Pleura yellow, vaguely marked with more reddish brown. Halteres obscure yellow, the knobs infuscated. Legs with the coxæ and trochanters yellow; femora obscure yellow, the tips blackened; tibiæ and tarsi passing into black. Wings (Plate 1, fig. 1) hyaline, iridescent; stigma brown; veins black, paler in the costal region. Venation: Rs and other elements of anterior cord in oblique to transverse alignment, cell R_3 lying more basad than cell R_5 ; R_{1+2} represented by a conspicuous spur that is subequal to or longer than R_2 ; forks of media deep; m-cu close to fork of M.

Abdominal tergites orange, each with a conspicuous blue-black area occupying the center of the disk, the pale apex of the segment a little narrower than the base; on outer segments the dark areas are more extensive, occupying most of the segments; sternites obscure yellow; hypopygium chiefly darkened, the styli and appendage of the ninth sternite yellow or orange. Male hypopygium (Plate 2, fig. 23) large and conspicuous. Ninth tergite, 9t, without heavy chitinization, the obtuse lateral lobes separated by U-shaped notch, set with short black spines and spinous setæ. Outer dististyle, *od*, a long projecting yellow rod, terminating in a blackened tip. Inner dististyle, *id*, considerably shorter, shaped as in figure. Conspicuous blackened bispinous structures that may be gonapophyses on either side of median line. Appendage of ninth sternite, 9s, a long, feebly sinuous, slender rod that is only slightly expanded at apex, directed caudad, the tip slightly more dorsad, the surface densely covered with short setulæ.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 to 5,800 feet, July 2 to 5, 1930 (*Clagg*); holotype, male; allotype, female; paratypes, 6 males and females. "Sweeping among ferns and undergrowth along margins of brook."

Scamboneura mindanaoensis is most closely related to *S. primæva* Alexander (Luzon), differing especially in details of venation and coloration of the præscutum. The male of *primæva* is still unknown.

SCAMBONEURA DAVAOENSIS sp. nov. Plate 2, figs. 24, 25, and 26.

General coloration yellow; antennæ (male) elongate; præscutum with three leaden stripes that are conspicuously bordered by velvety black; a median dark area on postnotal mediotergite; wings with anterior cord strongly bowed; male hypopygium with the tergite produced medially; outer dististyle a short and broad ear-shaped lobe; appendage of ninth sternite short and broad.

Male.—Length, about 14 millimeters; wing, 12; antennæ, about 5.5.

Female.—Length, about 18 millimeters; wing, 15.

Frontal prolongation of head yellow, weakly infuscated dorsally; nasus black; palpi obscure yellow, the terminal segment blackened. Antennæ (male, elongate; scape brownish yellow; flagellum black, the apices of the basal segments restrictedly obscure yellow; female with antennæ shorter, the bicolourous nature more conspicuous. Head obscure yellow, the occipital region and a line therefrom onto vertex brownish black.

Pronotum blackened laterally, yellowish white medially. Mesonotal præscutum yellow, with three leaden stripes that are conspicuously bordered by velvety black; lateral margins of sclerite and a spot laterad of anterior end of lateral stripe blackened; scutum yellow, the lobes conspicuously blackened; scutellum brownish black, the base more yellow; parascutella black, their anterior margin yellow; postnotal mediotergite yellow, a median line and the posterior margin blackened. Pleura yellow, variegated with brown and reddish brown. Halteres blackened. Legs with the coxæ and trochanters yellow; femora obscure yellow, narrowly infuscated at tips; tibiæ brownish yellow, the tips narrowly blackened; tarsi black. Wings subhyaline, iridescent; stigma pale brown; veins black. Macrotrichia of veins elongate. Venation: Elements of anterior cord strongly bowed, as in the other specialized members of the genus; forks of medial field deep.

Abdominal tergites dull orange, the disk of each with a blue-black area, this becoming more extensive on the outer segments; lateral margins of tergite darkened; hypopygium blackened. Male hypopygium small. Ninth tergite (Plate 2, fig. 24) with the median area further produced, with a small V-shaped median notch. Outer dististyle, *od* (Plate 2, fig. 25), a short, broad, ear-shaped lobe. Inner dististyle, *id* (Plate 2, fig. 25), unusually small, heavily blackened. Appendage of ninth sternite, 9s

(Plate 2, fig. 26), a short broad lobe, the lateral angles with coarse setæ, these becoming shorter and less conspicuous toward the obtuse apex of the lobe.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 2 to 5, 1930 (*Clagg*); holotype, male; allotype, female; paratype, male. "Among ferns and mossy trees."

Scamboneura davaoensis is most closely related to *S. dotata* Osten Sacken (Luzon), from which it differs in the longer and more nearly uniformly blackened antennæ of the male and the details of structure of the hypopygium, notably of the tergite.

DOLICHOPEZA (NESOPEZA) SPINISTERNATA sp. nov. Plate 1, fig. 2; Plate 2, fig. 27.

Belongs to the *gracilis* group; closely allied to *gracilis* de Meijere; general coloration yellow; antennæ elongate, pale yellow; mesonotal præscutum with three very poorly indicated pale brown stripes; pleura yellow; femoral tips weakly darkened; wing pattern much as in *gracilis*, the costal darkening not including cell R_3 ; medial forks of moderate depth; male hypopygium with each lateral angle of the sternite produced into a powerful spine that is composed of fasciculate black bristles.

Male.—Length, about 8 millimeters; wing, 8.5; antennæ, about 3.8.

Rostrum and palpi black. Antennæ (male) elongate, as shown by the measurements; yellow, the outer segments a very little darkened; flagellar segments elongate-cylindrical. Head brownish gray, narrowly clearer gray on the orbits; anterior vertex about three times as wide as the first scapal segment.

Mesonotum yellow, the præscutum with very poorly indicated pale brown stripes; scutal lobes with similar scarcely indicated markings; scutellum and postnotum more testaceous. Pleura pale yellow, unmarked. Halteres yellow, the knobs infuscated. Legs with the coxæ and trochanters pale yellow; femora yellow, the tips broadly but weakly darkened; tibiæ yellowish white, the tips narrowly blackened; tarsi white. Wings (Plate 1, fig. 2) whitish subhyaline, with a brown, chiefly costal, pattern that is arranged much as in *gracilis*; costal darkening ending at vein R_3 , cell R_3 being entirely clear; pale area in cell Sc_2 very extensive, the darkened portions restricted to the ends of the cell. Venation: Forks of medial field of moderate depth; cell 2d A relatively wide.

Abdominal tergites obscure yellow, the caudal margins of the basal segments weakly darkened, the outer segments more extensively so; sternites chiefly yellow, the caudal margins very

narrowly to scarcely darkened; hypopygium brownish yellow. Male hypopygium (Plate 2, fig. 27) with the lateral arms of the tergite, 9t, blackened, obtuse, provided with a few small black spinous points. Lateral angles of the sternite, 9s, produced into a powerful spine comprised of groups of fasciculate black setæ; median region of sternite at margin with further conspicuous black setæ. Outer dististyle a very small pale lobe, about as long as the beak of the inner dististyle.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 4, 1930, by sweeping (*Clagg*); holotype, male.

DOLICHOPEZA (NESOPEZA) PAUCISPINOSA sp. nov. Plate 2, fig. 28.

Belongs to the *gracilis* group; closely allied to *gracilis* de Meijere; mesonotal præscutum and pleura distinctly patterned with dark brown; wings light gray, with a heavy costal pattern; medial forks deeper than in *gracilis*; male hypopygium with the spines of the sternite relatively few in number.

Male.—Length, about 8.5 millimeters; wing, 9.5.

Female.—Length, about 9.5 millimeters; wing, 9.5.

Rostrum and palpi black. Antennæ with the basal segments obscure yellow, the flagellar segments passing into brown. Head gray, with a transverse brown marking connecting the eyes on the posterior vertex.

Mesonotal præscutum whitish, the median stripe dark brown, conspicuous; lateral stripes less evidently defined; scutum whitish, each lobe with two confluent brown marks; scutellum and posnotum pale brown. Pleura pale, variegated with dark brown on the anepisternum, ventral sternopleurite, meron, and narrowly on the ventral pleurotergite. Halteres with the stem dusky, the extreme base pale yellow, the knobs blackened. Legs with the coxæ and trochanters pale yellow; femora yellow, the tips conspicuously brown, the proximal half of this ring more intense, blackened; tibiæ whitish yellow, the tips narrowly darkened; tarsi white. Wings light gray, with a conspicuous dark brown costal pattern, arranged as in *gracilis*; two isolated whitish spots beyond the solid costal darkening, the first occupying the distal three-fifths of cell Sc₂, the second the outer end of cell R₃; dark seams at origin of Rs and in proximal end of cell R narrower than in *gracilis*. Venation: Distal end of vein R₃ strongly upcurved, widening cell R₃; medial forks deeper than in *gracilis*, the petioles of the cells correspondingly shortened; cell 2d A narrow.

Abdominal tergites dark brown, the basal segments variegated laterally with pale before their ends, the amount of dark color-

ing increasing outwardly; hypopygium chiefly dark. Male hypopygium (Plate 2, fig. 28) with the tergite, 9t, blackened, the lateral arms obtuse at tips, each provided with about fifteen small tubercles; median region of tergite weakly produced. Outer dististyle, *od*, short and stout. Sternite, 9s, with the spines large and conspicuous but reduced in number, there being about five or six on the lateral lobes, of which three or four are on the lateral portion, the others, shorter and stouter, on the mesial portion; median lobe of sternite with about eight spines, there being about four on each lateral angle.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 to 5,800 feet, July 2 to 3, 1930, by sweeping (*Clagg*); holotype, male; allotype, female.

The female is much darker than the male but seems undoubtedly to be conspecific. The dark markings of the thorax are more intense and contrast strongly with the ground color.

LIMONIINÆ

LIMONIINI

LIMONIA (LIMONIA) CLAGGI sp. nov. Plate 1, fig. 3; Plate 2, fig. 29.

General coloration black; anterior vertex silvery; præscutal stripes and centers of scutal lobes brownish yellow; legs black, the tips of the tibiæ and the tarsi paling to yellow; tarsal claws edentate; wings dusky, with a heavy dark brown pattern that is bordered by cream-colored areas; Sc long, Sc₁ extending to beyond r-m; Rs short, strongly angulated at origin; m-cu beyond fork of M; anal veins strongly curved to the wing margin; male hypopygium with the rostral prolongation long and slender, expanded at apex, provided with a single black spine; at base of prolongation from face of style a long pale basal tubercle tipped with a black spine.

Male.—Length, about 7.5 millimeters; wing, 8.5.

Rostrum dark brown; palpi black. Antennæ black; flagellar segments long-oval, with short glabrous apical necks; segments densely clothed with black setulæ and additional verticils, the longest of the latter unilaterally arranged and slightly exceeding the segments. Head black, the front and anterior vertex silvery; anterior vertex narrower than the diameter of the scape.

Pronotum dark brown. Mesonotal præscutum black, the usual stripes brownish yellow; scutal lobes with brownish yellow centers, the borders black; scutellum and postnotal mediotergite dark brown to black, sparsely pruinose. Pleura black, the sternopleurite paler, brown. Halteres with the stem yellow, infus-

cated on middle half, the knobs dark brown. Legs with the coxæ yellow, the mid-coxæ darker; trochanters obscure yellow; femora brownish black, the bases restrictedly paler; genua very narrowly and indistinctly brightened; tibiæ black, the extreme tips paling to yellowish; tarsi yellow, the terminal segments darkened; claws (male) long and slender, edentate. Wings (Plate 1, fig. 3) suffused with dusky, with a heavy brown pattern that is bordered by cream-colored areas; a very extensive brown costal area extends from before Rs to beyond the fork of Sc; other major dark areas as follows: At h and arculus; R_2 and R_{1+2} ; center of cell R_2 at margin; tips of veins R_3 , R_{4+5} , Cu_1 , and the anal veins; a series of three spots, one each in cells R_5 , 2d M_2 , and M_3 , in a line that parallels the wing margin; conspicuous seams on cord and outer end to cell 1st M_2 ; veins brown; outer portion of costa more incrassated, brownish black, with four conspicuous yellow areas, the first in cell Sc_1 , two in cell R_2 , the last, smallest, in cell R_3 . Venation: Sc long, Sc_1 ending beyond r-m, Sc_2 at its tip; Rs short, very strongly angulated at origin; basal section of R_{4+5} nearly as long as Rs; cell 1st M_2 closed; m-cu about one-half its length beyond the fork of M, a trifle longer than the distal section of Cu_1 ; anal veins curved strongly to the wing margin.

Abdominal tergites brownish black, the sternites with a broad obscure yellow basal triangle; hypopygium dark. Male hypopygium (Plate 2, fig. 29) with the caudal margin of the tergite, 9t, very gently emarginate. Basistyle, *b*, of moderate size, the ventromesal lobe obtuse, basal in position. Dorsal dististyle a nearly straight rod, the curved apex blackened, the outer margin with abundant appressed spinulæ. Ventral dististyle, *vd*, oval, with conspicuous setæ; rostral prolongation long and slender, at apex more expanded, on outer margin with a black spine; at base of prolongation on face of style a long slender rodlike tubercle that bears the second spine, this short, about one-fifth the length of the pale base. Gonapophyses, *g*, broad, the apex a short, more-chitinated beak; a weak lobe on mesal edge. Ædeagus, *a*, large, the apex obtuse.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,800 feet, July 3, 1930 (*Clagg*); holotype, male. "Sweeping in ferns and undergrowth along margins of small brook."

Limonia (*Limonia*) *claggi* is named in honor of the collector, Mr. Charles F. Clagg, to whom I am very greatly indebted for invaluable crane flies from the high mountains of Mindanao. The species obviously belongs to the *trigonia* group, having Sc

unusually long and with m-cu beyond the fork of M. The latter characters would serve to place the species of the *trigonia* group in the subgenus *Libnotes*, whereas their true affinities seem to lie with *Limonia* s. s.

LIMONIA (LIMONIA) SYNCHÆTA sp. nov. Plate 1, fig. 4; Plate 2, fig. 30.

General coloration black, the præscutum with three reddish brown stripes; halteres infuscated; legs black; wings with a strong brown tinge, sparsely seamed along cord and outer end of cell 1st M_2 with darker brown; stigmal area restricted to a narrow seam at the fork of R_1 ; male hypopygium with the two rostral spines of the ventral dististyle arising basad of a long yellow boomerang-shaped structure, the spines from a common fused base that divides into unequal pale tubercles.

Male.—Length, about 6 to 8 millimeters; wing, 7 to 9.5.

Rostrum and palpi black. Antennæ black throughout; basal flagellar segments subglobular, the outer segments passing into oval; verticils relatively inconspicuous, on basal segments shorter than the segments themselves, on outer segments becoming more elongate. Head black.

Pronotum black. Mesonotal præscutum black, the three usual stripes reddish brown; scutal lobes with centers reddish brown, bordered by blackish; scutellum chiefly pale; postnotal mediotergite darkened on anterior portion, paler behind. Pleura chiefly dark brown, vaguely brightened in places, as on the ventral sternopleurite; dorsopleural region pale. Halteres infuscated, the extreme base of stem brightened. Legs with the coxæ and trochanters obscure yellow; remainder of legs black; claws long and slender, with a single acute basal spine. Wings (Plate 1, fig. 4) with a strong brown tinge, restrictedly patterned at origin of R_s , along cord and outer end of cell 1st M_2 , and as a narrow stigmal seam at the fork of R_1 with darker brown; veins darker brown. Costal fringe of moderate length. Venation: Sc_1 ending about opposite three-fourths the length of R_s , Sc_2 at its tip; R_s nearly square at origin; free tip of Sc_2 opposite or a little before the level of R_2 ; m-cu just before the fork of M.

Abdominal tergites black, the basal sternites black, their bases restrictedly pale; hypopygium chiefly dark. Male hypopygium (Plate 2, fig. 30) with the caudal margin of the tergite, 9t, very gently emarginate, the very low lateral lobes with long coarse setæ. Basistyle, b, relatively short and stout, the ventromesal lobe broad, basal in position, at apex with a smaller lobule that bears two long and two short setæ. Ventral dististyle, vd,

relatively small and oval, the rostral prolongation a long, pale yellow, boomerang-shaped structure, the usual spines arising from a common flattened base that branches into two unequal tubercles, the outer longer, bearing a somewhat longer spine, the inner tubercle short, its spine a trifle shortened. Dorsal dististyle with the outer margin with microscopic spinulæ. Gonapophyses, *g*, with the mesal-apical lobe relatively slender, smooth, and gently curved.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,800 feet, July 3, 1930 (*Clagg*); holotype, male. "Among ferns and undergrowth along margins of small brook;" Mount Apo, 7,000 feet, September 11, 1930 (*Clagg*); paratype, male. LUZON, Laguna Province, above Ube, altitude about 1,625 feet, December 22, 1929 (*McGregor*); paratype, male.

Limonia (*Limonia*) *synchæta* is well-distinguished by the peculiar structure of the male hypopygium. The type is smaller than the paratype but is undoubtedly conspecific.

LIMONIA (LIMONIA) PLEIADES sp. nov. Plate 1, fig. 5; Plate 2, fig. 31.

General coloration castaneous; wings with the cephalic half strongly suffused with brown, the posterior half gray; seven circular to oval whitish hyaline droplets in cells of wing, these slightly ringed with darker; male hypopygium with the rostral prolongation remote from the basal spine of the ventral dististyle.

Male.—Length, about 5.5 millimeters; wing, 4.8 to 5.

Female.—Length, about 6 millimeters; wing, 5.5.

Rostrum and palpi small, dark brown. Antennæ dark brown; basal flagellar segments subglobular, becoming oval and then elongate-oval outwardly, the segments on outer face with very long verticils, those on the inner face shorter but still long and conspicuous. Head blackened behind, heavily pruinose with silvery, especially on the front and anterior vertex, the latter wide in both sexes.

Pronotum brownish black. Mesonotum castaneous, nitidous, the pleura more variegated with darker. Halteres dark brown. Legs with the coxæ and trochanters yellow; femora yellow, the tips slightly enlarged and conspicuously blackened, the amount subequal on all legs; fore tibiæ black, the other tibiæ paler, tipped with black; tarsi black; claws long and slender, with an elongate spine at near one-third the length, together with two additional progressively smaller spines at base. Wings (Plate 1, fig. 5) with the cephalic half strongly suffused with brown, the posterior cells paler, more grayish; cord and outer end of

cell 1st M_2 seamed with darker brown, in cases suffusing the stigmal region and adjoining portions of the radial field; axilla weakly darkened; seven circular to oval whitish-hyaline areas, one each in cells R , R_1 , Sc_1 , R_2 , R_3 near outer end, center of 1st M_2 , and near base of 2d M_2 , these droplets narrowly bordered by brown; veins dark brown. Venation: Sc long, Sc_1 ending about opposite four-fifths to five-sixths Rs , Sc_2 at its tip; $m-cu$ at fork of M . The hyaline droplets distort the following veins: $Costa$ and R just beyond the fork of Sc , Rs just before midlength, R_3 just beyond R_2 , R_{4+5} near outer end, second and third sections of M_{1+2} , and outer section of M_3 before midlength.

Basal abdominal tergites black, the caudal portions broadly black; outer tergites black, with metallic green reflections; basal sternites similarly dimidiate yellow and black, the outer segments dull black; hypopygium chiefly yellow, the basistyles darkened apically. Male hypopygium (Plate 2, fig. 31) with the caudal margin of the tergite, $9t$, very shallowly notched. Basistyle, b , long and slender, the ventromesal lobe relatively small. Dorsal dististyle nearly straight, the apex a little expanded, narrowed to an acute point. Ventral dististyle, vd , small, fleshy, the cephalic mesal portion produced into a slender rod that is tipped by a long black spine; mesal face of style at near midlength bearing the rostral prolongation, the latter at near midlength with a slender hairlike spine. Gonapophyses with the mesal-apical lobe slender, the tip acute. $\text{\AA}edeagus$, a , bifurcate at tip. Ovipositor with the genital shield of the tergal valves very large, the valves correspondingly reduced; sternal valves very large.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 4 and 5, 1930, by sweeping (*Clagg*); holotype, male; allotype, female; paratypes, 2 males; Mount Apo, 7,000 to 8,000 feet, September 21, 1930 (*Clagg*); paratypes, 1 male and 1 female.

The specific name of this charming fly is derived from the seven conspicuous droplets on the wing membrane. I can suggest no closely allied form.

LIMONIA (LIMONIA) PRONOTALIS sp. nov. Plate 1, fig. 6.

Head obscure yellow, blackened behind; pronotum orange; mesonotum blue-black, the sides of the præscutum and the dorsopleural region intensely black; knobs of halteres ivory white; fore femora black, the basal fourth pale; tibiæ darkened; wings suffused with brown, the prearcular and costal regions more whitish, without a pale crossband before the cord.

Female.—Length, about 5.5 millimeters; wing, 5.3.

Rostrum and mouth parts very much reduced to nearly lacking. Antennæ with the scape obscure yellow, the flagellum black; basal flagellar segments short, subglobular, their ends truncated, the outer segments more elongate and slender; verticils of basal segments short and inconspicuous, outwardly becoming longer, subequal to or exceeding the segments. Front obscure yellow, the broad vertex more-polished black.

Pronotum fiery orange. Mesonotal præscutum polished blue-black, more intensely blackened on the sides; humeral region obscure yellow; median region of præscutum and scutum brightened at suture; remainder of notum blue-black. Pleura with the dorsopleural region intense black; sternopleurite paler, more brownish; pleurotergite black. Halteres brown, the knobs ivory white. Legs with the coxæ and trochanters pale yellow; fore femora black, only the basal fourth pale; middle and posterior femora yellow with about the distal seventh blackened; fore tibiæ black, the other tibiæ somewhat paler, tipped with black; tarsi brown; claws with a subobtuse basal tooth that bears a long pale seta. Wings (Plate 1, fig. 6) with a uniform brown suffusion, the prearcular and costal regions more whitish, the latter involving the base of cell R; stigma small, ill-delimited; no hyaline crossband before cord, as in *citrofocalis*; veins dark brown. Venation: Sc₁ ending at near midlength of Rs, Sc₂ at its tip; free tip of Sc₂ pale, subequal to the section of R₁ beyond; R₂ pale, without macrotrichia; basal section of R₄₊₅ strongly arcuated; cell 1st M₂ closed; m-cu at fork of M, long, sinuous, exceeding the distal section of Cu₁; anal veins parallel at base.

Abdominal tergites black, the subterminal segment abruptly light yellow; sternites conspicuously pale medially, the lateral portions darkened; genital segment black. Ovipositor with the tergal valves slender, strongly upcurved.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 2, 1930 (*Clagg*); holotype, female. "Among ferns and on mossy trees;" Mount Apo, 6,000 to 7,000 feet, September 1 to 11, 1930 (*Clagg*); paratypes, 4 males and females.

Limonia (*Limonia*) *pronotalis* is most closely allied to *L.* (*L.*) *citrofocalis* (Edwards), of Borneo, differing most evidently in the uniformly infuscated wings, without a hyaline crossband before the cord, together with the details of coloration of body and fore femora.

LIMONIA (LIMONIA) CYNOTIS sp. nov. Plate 1, fig. 7; Plate 2, fig. 32.

General coloration dark brown; antennæ black throughout; knobs of halteres and the legs blackened; wings with a strong blackish suffusion; male hypopygium with the dististyle single, shaped more or less like a dog's ear, the mesal face densely hairy.

Male.—Length, about 5 millimeters; wing, 5.2.

Female.—Length, about 5.5 millimeters; wing, 5.8.

Rostrum dark brown; palpi black. Antennæ black throughout; basal flagellar segments globular, the outer ones more oval, with short verticils. Head black.

Pronotum dark brown. Mesonotum uniformly dark brown, the surface subnitidous. Pleura brown, a little paler than the notum; dorsopleural membrane blackened. Halteres dusky, the base of stem restrictedly brightened, the knobs blackened. Legs with the coxæ pale brown; trochanters yellow; remainder of legs black. Wings (Plate 1, fig. 7) with a strong blackish suffusion; stigma lacking; veins darker than the ground color. Venation: Sc_1 ending just before midlength of Rs , Sc_2 at its tip; Rs long; free tip of Sc_2 perpendicular, some distance before R_2 ; $m-cu$ close to fork of M ; vein $2d$ A relatively long.

Abdomen, including the hypopygium, black. Male hypopygium (Plate 2, fig. 32) with the tergite, $9t$, large. Basistyle, b , with the ventromesal lobe relatively small. A single dististyle, d , shaped more or less like a dog's ear, broad at base, narrowed outwardly to a point, the mesal face densely set with erect black setæ; outer margin of style near base with a small hemispherical tubercle that bears two large setæ. Gonapophyses, g , with the mesal-apical lobes appearing as elongate dusky blades. $\mathcal{A}$ edeagus, a , large, bifid at apex, the surface with abundant erect microscopic setulæ.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,800 feet, July 2 and 3, 1930 (*Clagg*); holotype, male; allotype, female; paratypes, 2 males and 2 females. "Among ferns and undergrowth along margins of brook."

Limonia (*Limonia*) *cynotis* is well distinguished by the combination of characters outlined above, more especially the uniformly blackened wings and peculiar structure of the male hypopygium.

LIMONIA (LIMONIA) PROLIXICORNIS sp. nov. Plate 1, fig. 8; Plate 2, fig. 33.

General coloration reddish brown; antennæ (male) elongate, nearly one-half the length of the body; halteres infuscated; wings tinged with brown; Sc_1 ending opposite or beyond mid-

length of Rs , Sc_2 a short distance from its tip; cell M_2 open by atrophy of m ; male hypopygium without dorsal dististyle; ventral dististyle subglobular, the rostral prolongation long and slender, without spines.

Male.—Length, about 3.3 to 3.4 millimeters; wing, 4.2; antennæ, about 1.5.

Female.—Length, about 4 millimeters; wing, 4.

Rostrum and palpi black. Antennæ black throughout, in male very elongate for a member of this genus, if bent backward extending about to one-third the length of the abdomen; flagellar segments long-oval to fusiform, the apical necks glabrous, the remainder of the segment with abundant erect setæ that are much shorter than the segments; no outstanding verticils. In female, antennæ much shorter, the segments oval to long-oval, with the verticils more evident. Head dark brown.

Mesonotum reddish brown, without markings. Pleura brownish testaceous, somewhat paler ventrally. Halteres infuscated, the extreme base of stem brighter. Legs with the coxæ and trochanters yellowish testaceous; remainder of legs brownish black; claws usually small, nearly straight, each with a group of slender spines at base. Wings (Plate 1, fig. 8) tinged with brown, the oval stigma slightly darker brown; veins dark brown. Venation: Sc_1 ending opposite or beyond midlength of Rs , Sc_2 slightly removed from its tip, Sc_1 alone being subequal or longer than R_2 ; cell M_2 open by the atrophy of m ; cell M_3 relatively deep; vein $2d$ A at origin converging rather strongly toward vein $1st$ A.

Abdominal tergites and hypopygium dark brown; basal sternites yellow, the outer segments passing into dark brown. Male hypopygium (Plate 2, fig. 33) with the tergite, $9t$, produced into long slender lateral lobes, their apices glabrous. Basistyle, b , relatively stout, the ventromesal lobe low and obtuse; mesal face of style with a dense area of long coarse setæ. Ventral dististyle, d , subglobular, nearly as large as the basistyle, the rostral prolongation very long and slender, slightly expanded at apex but unprovided with rostral spines. Dorsal dististyle lacking. Gonapophyses, g , with the mesal-apical lobe recurved at apex, the margin toothed. Ædeagus, a , divided at apex into four lobes.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 to 5,800 feet, July 2 to 4, 1930 (*Clagg*); holotype, male; allotype, female; paratypes, 7 males and females. "Among ferns and on mossy trees, everything very damp."

Limonia (*Limonia*) *prolixicornis* is apparently closely allied to *L. (L.) pacata* Alexander (Luzon), differing in the details of venation, as the longer Sc and Sc₁, and deeper cell M₃. Unfortunately, the male of *pacata* is still unknown, and the nature of the antennæ and the male hypopygium cannot be stated.

LIMONIA (LIMONIA) PILOSICAUDATA sp. nov. Plate 1, fig. 9; Plate 2, figs. 34, 35.

General coloration brownish yellow, the præscutum darkened medially behind; femora brownish yellow, more yellowish at tips, this area inclosing a black ring; wings tinged with brown, with a darker brown seamed and spotted pattern; abdominal tergites bicolorous; male hypopygium large and complicated in structure; tergite tumid, with abundant long yellow setæ; ventral dististyle oval, produced at apex into a very long hairy lobe; rostral prolongation very small, at base with a small tubercle that bears two long setoid spines.

Male.—Length, about 8 to 9 millimeters; wing, 9 to 9.5.

Female.—Length, about 10 millimeters; wing, 10 to 11.

Rostrum and palpi black, the former produced, nearly as long as the remainder of head. Antennæ black throughout; flagellar segments subcylindrical, becoming more elongate outwardly, the verticils barely exceeding the segments; terminal segment elongate, about one-half longer than the penultimate. Head dark gray; anterior vertex reduced to a linear strip.

Pronotum brown. Mesonotal præscutum brownish yellow, the median region behind weakly darkened, the stripes otherwise lacking; scutal lobes conspicuously infuscated, the median region pale; scutellum pale basally, margined with darker; post-notal mediotergite dark brown, paler laterally. Pleura generally brownish yellow, the dorsopleural region infuscated. Halteres yellow, the knobs blackened. Legs with the coxæ brownish yellow; trochanters yellow; femora brownish yellow, with a conspicuous black subterminal ring preceded and followed by narrow clearer yellow annuli; tibiæ brown; tarsi passing to darker brown; claws relatively small, with an acute spine and a more-basal seta on proximal third. Wings (Plate 1, fig. 9) tinged with brown, cells C, Sc, and a conspicuous seam along the cubital veins darker brown; stigma small, oval, dark brown; narrow brown seams at origin of Rs, along cord, and on outer end of cell 1st M₂; veins dark brown, paler brown in the costal region. Venation: Sc₁ ending shortly beyond the fork of Rs, Sc₂ near its tip; Rs long, arcuated to weakly angulated at origin; anterior branch of Rs forming a regular curve; cell 1st M₂ long, m-cu close to fork of M.

Abdominal tergites bicolorous, their bases darkened, the apices yellow, the amount of the latter decreasing on the outer segments; sternites more uniformly yellow; hypopygium generally dark brown. Male hypopygium (Plate 2, fig. 34) very large and complicated in structure. Ninth tergite (Plate 2, fig. 35) with the lobes tumid, separated on caudal margin by a small notch, the lobes with very abundant long erect yellow setæ, much longer than the tergite itself. Basistyle, *b*, relatively small, the ventromesal lobe very long, bearing a smaller lateral lobule on basal half, the apex of the lobe conspicuously setiferous. Ventral dististyle, *vd*, an oval structure that is greatly produced at apex into a long-cylindrical hairy lobe; on dorsal face of style a blackened short-hairy lobe, in the notch of which lies the long sinuous dorsal dististyle (not figured); the usual rostral prolongation is a small slender lobe, at base with a small tubercle bearing two very elongate setoid spines. Gonapophyses, *g*, with the mesal-apical lobe a blackened hook. Ovipositor with the tergal valves long and slender, gently upcurved; sternal valves long and straight.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 2 to 5, 1930 (*Clagg*); holotype, male; allotype, female; paratypes, 2 males. "Among ferns and on mossy trees; sweeping in ferns and undergrowth along margins of small brook;" Mount Apo, 6,500 to 8,000 feet, September 10 to 21, 1930 (*Clagg*); paratypes, 8 of both sexes.

Limonia (*Limonia*) *pilosicaudata* might be construed as falling within the limits of the subgenus *Libnotes* but shows certain characters of the typical subgenus wherein I am retaining it. The very peculiar structure of the male hypopygium is distinctive.

LIMONIA (LIMONIA) DAVAOENSIS sp. nov. Plate 1, fig. 10; Plate 3, fig. 36.

General coloration obscure yellow, the præscutum with three confluent brown stripes; antennæ black throughout; a narrow dark brown pleural stripe; knobs of halteres infuscated; wings with a faint brown tinge, the circular stigma darker; male hypopygium with a slender lobe on basistyle, in addition to the long ventromesal lobe; dorsal dististyle pale, straight, hairy; ventral dististyle without rostral spines; gonapophyses with the margin microscopically serrulate.

Male.—Length, about 4.6 to 5 millimeters; wing, 5.2 to 5.8.

Female.—Length, about 5.5 millimeters; wing, 6.

Rostrum and palpi black. Antennæ black throughout; segments oval, with very short apical necks; outer segments more

elongate, the terminal one pointed; verticils short. Head dark brown; anterior vertex (male) reduced to a narrow strip.

Pronotum black, the anterior lateral pretergites yellow. Mesonotal præscutum obscure yellow, the central portion covered by three confluent dark brown stripes, the lateral stripes continued caudad onto the scutal lobes; median area of scutum pale; posterior sclerites of mesonotum infuscated. Pleura yellow, with a distinct dark brown longitudinal stripe that extends from the pronotum to the abdomen, passing beneath the halteres. Halteres infuscated, the extreme base of stem yellow. Legs with the coxæ and trochanters pale yellow; femora brownish yellow, brighter at base, passing into brown at tip; tibiæ and tarsi dark brown; claws relatively long and slender, with a single acute spine near base. Wings (Plate 1, fig. 10) with a faint brown tinge, the prearcular and costal regions a trifle more yellow; wing tip slightly darkened; stigma circular, pale brown; veins dark brown. Venation: Sc_1 ending about opposite two-thirds the length of the arcuated Rs , Sc_2 at its tip; free tip of Sc_2 and R_2 in transverse alignment; m-cu close to the fork of M ; vein 2d A at base converging slightly toward 1st A.

Abdominal tergites dark brown, the extreme caudal margins of the segments ringed with reddish brown; sternites more uniformly darkened; hypopygium dark brown. Male hypopygium (Plate 3, fig. 36) with the tergite, 9t, long, gradually narrowed outwardly, the narrow apex subtruncate to very weakly concave; a marginal series of about five coarse setæ on either side. Basistyle, *b*, with the ventromesal lobe basal in position, very long, narrowed outwardly, provided with long coarse setæ, with a small basal lobule in axil; on mesal face of style but more apical in position a slender dark lobe that terminates in about six stout yellow setæ. Dorsal dististyle a pale straight rod, narrowed to a point, the tip acute. Ventral dististyle, *vd*, relatively small, of unusual form, with two dusky setiferous lobes at base; rostral blade stout, without evidently developed spines. Gonapophyses, *g*, with the outer margin of the mesal-apical lobe with abundant microscopic sawlike teeth or ridges. Ovipositor with the valves long and slender.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 to 5,800 feet, July 3 and 4, 1930 (*Clagg*); holotype, male; allotype, female; paratypes, 3 males. "Among ferns and undergrowth along margins of small brook;" Mount Apo, 7,000 to 8,000 feet, September 30, 1930 (*Clagg*); paratype, male.

Limonia (Limonia) davaoensis is very distinct from other regional species in the peculiar structure of the male hypopygium.

LIMONIA (LIMONIA) CALIANENSIS sp. nov. Plate 1, fig. 11; Plate 3, fig. 37.

General coloration brown; antennæ black throughout; mesonotal præscutum brown, with three yellow stripes; pleura yellow, with a broad black longitudinal stripe; wings pale brown, unmarked; abdomen black, the basal sternites yellow; male hypopygium with the basistyle long and slender, the ventromesal lobe extensive, appressed to the face of the style; ventral dististyle relatively small, the two spines of the rostral prolongation long, appressed to the face of the prolongation, blunt or weakly notched at tips.

Male.—Length, about 5.2 millimeters; wing, 6.2.

Rostrum small, brownish yellow; palpi black. Antennæ black throughout; basal segments short-oval, with short glabrous apical necks; outer segments more elongate-oval, terminal segment about one-third longer than the penultimate; flagellar verticils long and conspicuous, the longest on the outer segments fully twice as long as the segments. Head rich brown; anterior vertex wider than the first scapal segment.

Pronotum dark in front, paler behind. Mesonotal præscutum brown, the three usual stripes yellow, the median one broad, the laterals narrow, crossing the suture onto the lateral portions of the scutal lobes; posterior sclerites of mesonotum chiefly darkened, the median area of the scutum and scutellum somewhat more testaceous. Pleura pale yellow, with a broad black longitudinal stripe extending from the pronotum to the abdomen, passing beneath the root of the halteres, leaving a pale area dorsad of this beneath the wing root and on the dorsal pleurotergite; dorsopleural region infuscated. Halteres brownish black. Legs with the coxæ and trochanters yellow; remainder of legs light brown, only the terminal tarsal segments darker; claws long and slender, with a single long basal spine. Wings (Plate 1, fig. 11) with a pale brown tinge, without markings; veins darker brown. Costal fringe of moderate length. Venation: Sc_1 ending at midlength of R_s , Sc_2 at its tip; free tip of Sc_2 and R_2 in transverse alignment; m-cu at fork of M; vein 2d A at origin converging very insensibly toward 1st A.

Abdominal tergites brownish black; basal sternites yellow, beyond the second passing into black; hypopygium dark brown.

Male hypopygium (Plate 3, fig. 37) with the ninth tergite, 9t, transverse, the caudal margin weakly concave, with about four submarginal setæ on either side. Basistyle, *b*, long and slender, the ventromesal lobe large, appressed to the mesal face of the style. Ventral dististyle, *vd*, much smaller than the basistyle, oval, the rostral prolongation conspicuous, chitinized; rostral spines two, basal in position, directed outward along the face of the prolongation; spines elongate, their tips blunt or weakly notched. Dorsal dististyle a gently curved chitinized rod, narrowed to the acute tip. Gonapophyses, *g*, with the mesal-apical lobe long and nearly straight, the margins smooth.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 3, 1930 (*Clagg*); holotype, male; Mount Apo, 8,000 feet, September 15, 1930 (*Clagg*); paratype, male.

Limonia (*Limonia*) *calianensis* is superficially like *L. (L.) ligayai* Alexander (Luzon) and other similar species but is amply distinct in the structure of the male hypopygium, in conjunction with other characters as outlined.

LIMONIA (LIBNOTES) BELLULA sp. nov. Plate 1, fig. 12; Plate 3, fig. 38.

General coloration pale yellow; mesonotal præscutum with an Δ -shaped black area that extends across the suture onto the scutal lobes; antennal flagellum pale; knobs of halteres and the femoral tips blackened; wings whitish subhyaline, with a heavy brown pattern, including a large area at arculus and a narrow lunate line before the wing tip; origin of R_s square, of R_{2+3} subangular; male hypopygium with the ventral dististyle large and fleshy, the rostral prolongation very short, with two unequal spines, the outer one widened into a pale flange.

Male.—Length, about 5.5 to 6 millimeters; wing, 5.8 to 6.5.

Female.—Length, about 6.5 millimeters; wing, 6.2.

Rostrum and palpi black. Antennæ with the scapal segments black, the flagellum much paler, brownish yellow; flagellar segments oval, becoming more slender and elongate outwardly; a unilateral series of very long verticils. Head gray; anterior vertex reduced to a linear strip.

Pronotum black, yellow laterally. Mesonotum yellow, the præscutum with Δ -shaped black area, consisting of the confluent median and lateral stripes, the posterior half of the former being replaced by yellow; lateral stripes crossing the suture onto the scutal lobes; scutellum pale yellow; postnotal mediotergite weakly infuscated. Pleura yellow. Halteres yellow, the knobs of the halteres black. Legs with the coxæ and trochanters

pale yellow; femora yellow, the tips narrowly but conspicuously blackened, the amount subequal on all legs; remainder of legs pale yellow; claws of moderate size, with a single developed spine. Wings (Plate 1, fig. 12) whitish subhyaline, the prearcular and costal regions more suffused with yellow; a heavy brown pattern, distributed as follows: At arculus, extending from costa to vein 1st A; origin of Rs, completely traversing cell R; stigma, extended caudad to vein R_{4+5} ; a narrow lunate darkening before wing tip, the concave side of the area being directed outward, extending from costa across the radial and medial fields to vein M_3 ; a narrow dark margin from cell R_2 into cell Cu; cord and outer end of cell 1st M_2 with narrow brown seams; an oval spot near end of vein 1st A; axilla narrowly darkened; veins yellow, brown where traversing the darkened areas; veins C, Sc, and R brighter yellow. Costal fringe relatively long and conspicuous; macrotrichia of veins beyond cord long and conspicuous. Venation: Sc ending just beyond fork of Rs, Sc_2 far from its tip; Rs strongly angulated to square at origin; R_{2+3} subangular at origin; m-cu at from one-third to one-half the length of cell 1st M_2 ; anal veins evenly diverging.

Abdominal tergites yellow, the caudal margin very broadly brownish black; sternites more uniformly pale; hypopygium yellow, the basistyles conspicuously darkened. Male hypopygium (Plate 3, fig. 38) with the tergite, 9t, unusually long, the caudal lobes very conspicuous, provided with long erect setæ. Basistyle, *b*, relatively small, the ventromesal lobe basal in position, small. Ventral dististyle, *vd*, very large and fleshy, the rostral prolongation small, with two very unequal spines, the outer unusually wide, its outer margin a pale flange, the inner spine small and delicate. Gonapophyses, *g*, with the mesal-apical angle microscopically serrulate along margin. Ædeagus slightly bifid at apex.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 to 5,800 feet, July 2 to 5, 1930 (*Clagg*); holotype, male; allotype, female; paratypes, 1 male and 1 female. "Among ferns and on mossy trees; among ferns and undergrowth along margins of a small brook;" Mount Apo, 7,000 feet, September 15, 1930 (*Clagg*); paratype, female. LUZON, Laguna Province, above Ube, February 3 to 9, 1930 (*Rivera*); paratypes, 7 males and females.

Limonia (*Libnotes*) *bellula* approaches very closely the characters of the subgenus *Goniodineura* van der Wulp. By Ed-

wards's key to the species of *Libnotes* ² the present species runs to couplet 58, disagreeing with both included species in all details of coloration. If the arcuation of the base of R_{2+3} is considered as being an angulation, the present species runs to couplet 54, *nigriceps* (van der Wulp), type of the subgenus *Goniodineura*.

HELIUS (HELIUS) TRIANGULIFERUS sp. nov. Plate 1, fig. 13.

General coloration reddish brown; rostrum and legs black; wings gray; anterior branch of Rs short, directed cephalad and fused for a short distance back from the margin with R_1 , forming a small closed triangular cell that is nearly filled by a gray stigmal area.

Male.—Length, about 3 millimeters; wing, 3.2.

Female.—Length, about 3.7 to 4 millimeters; wing, 3.8 to 4.2.

Rostrum about as long as the remainder of head, black; palpi black. Antennæ black throughout. Head black.

Mesonotum and pleura light reddish yellow, unmarked, darker in the paratype. Halteres infuscated. Legs with the coxæ and trochanters brownish yellow; remainder of legs black, the femoral bases restrictedly pale; terminal tarsal segments paling to yellowish brown. Wings (Plate 1, fig. 13) gray, the stigma slightly darker gray, almost filling the triangular cell R_1 ; a narrow apical clouding in cell R_3 ; veins dark brown. Costal fringe (male) relatively long and conspicuous. Venation: Sc_1 ending just beyond origin of Rs, Sc_2 shortly before this origin; anterior branch of Rs (R_{2+3}) very short, fused for a short distance back from the margin with R_1 , forming a small closed triangular cell; cell R_3 at margin correspondingly extensive; inner end of cell 1st M_2 arcuated; m-cu at or close to fork of M.

Abdomen dark brown. Ovipositor with the valves very long and slender, blackened.

LUZON, Laguna Province, above Ube, February 11, 1930 (*Rivera*); holotype, male; allotype, female. MINDANAO, Davao district, Calian, La Lun Mountains, at trap lantern, altitude 5,500 feet, July 4, 1930 (*Clagg*); paratype, female; Mount Apo, 6,000 feet, September 23, 1930 (*Clagg*); paratype, female.

The peculiar venation suffices to distinguish the present species. The Mindanao paratypes are slightly larger and darker but seem unquestionably to belong here.

² Journ. Fed. Malay States Mus. 14 (1928) 74-80.

HEXATOMINI

Genus EPIPHRAGMA Osten Sacken

Subgenus POLYPHRAGMA novum

Characters as in *Epiphragma* s. s., differing as follows: Basal segments of antennal flagellum united into a fusion segment; supernumerary crossveins and spurs in cell C, additional to the one normally present; a weak supernumerary crossvein in cell Cu, this rarely lacking.

Type of the subgenus, *Epiphragma bakeri* Alexander (Oriental Region).

Besides the subgenotype, the following species belong here: *Epiphragma cinereinota* Alexander, *crenulata* Alexander, *flavosternata* Alexander, *fulvinota* sp. nov., *fuscinota* sp. nov., *fusco-sternata* Alexander, *ochrinota* Alexander, *subcrenulata* Alexander, and *triarmata* sp. nov. All the known species of the subgenus are from the Philippines and Borneo.

EPIPHRAGMA (POLYPHRAGMA) FUSCINOTA sp. nov. Plate 1, fig. 14; Plate 3, fig. 39.

General coloration of mesonotum brown; femora brown; in cases with the tips abruptly pale yellow; tarsi yellow; wings gray, the ground color almost obliterated by a heavy brown pattern; cell 2d A uniformly darkened; male hypopygium with the interbasal process expanded at apex into a simple smooth blade.

Male.—Length, about 7.5 to 8 millimeters; wing, 8.5 to 9.

Rostrum and palpi black. Antennæ black, the fusion segment only slightly brightened. Head with the vertex obscure fulvous, with a median dark brown vitta and a posterior orbital darkening.

Posterior pronotum obscure yellow. Mesonotum generally brown, the humeral and lateral portions of the præscutum somewhat darker brown. Pleura somewhat darker brown than the notum, the ventral sternopleurite paling to yellowish. Halteres elongate, obscure yellow, the knobs darkened. Legs with the fore coxæ obscure yellow, the other coxæ somewhat darker; trochanters obscure yellow; femora infuscated, the bases brightened, the tips narrowly and abruptly yellow; tibiæ brown, the tips paling to obscure brownish yellow; tarsi yellowish. The Luzon paratype lacks the yellow femoral tips. Wings (Plate 1, fig. 14) gray, the costal region more yellowish gray, the ground

color chiefly obliterated by a very heavy brown pattern, darker brown along the costal margin; cell 2d A uniformly darkened. Venation: Supernumerary crossveins and spurs in cell C relatively few in number; Rs angulated to short-spurred at origin; m-cu variable in position, in the holotype figured being at mid-length of cell 1st M_2 , in the paratype less than its own length beyond the fork or M.

Abdominal tergites dark brown; sternites weakly bicolorous, obscure brownish yellow, the incisures and, more especially, the bases of the segments infuscated; hypopygium chiefly dark. Male hypopygium (Plate 3, fig. 39) with the outer dististyle, *od*, a chitinized rod, the tip curved into an acute spine, before apex with a small ventral tooth. Inner dististyle, *id*, expanded at apex into a head, the outer margin with a subspinous crest. Interbasal process, *i*, elongate, at apex expanded into a smooth, flattened obtuse blade.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,800 feet, July 3, 1930 (*Clagg*); holotype, male. "Sweeping ferns and undergrowth along margins of small brook." LUZON, Laguna Province, above Ube, February 3 to 9, 1930 (*Rivera*); paratype, male.

The paratype is slightly smaller and differs in details of leg coloration and wing venation from the type. However, the structure of the male hypopygium is the same, and I must regard the two specimens as being conspecific.

EPIPHRAGMA (POLYPHRAGMA) FULVINOTA sp. nov. Plate 1, fig. 15; Plate 3, fig. 40.

Mesonotum dull fulvous, the pleura brownish black; legs yellow, the femora with a broad dark brown subterminal ring; wings yellowish brown, the costal region brighter yellow; a heavy brown pattern, the areas not bordered by paler; male hypopygium with the base of the outer dististyle elevated into abundant points to produce a crownlike appearance; interbasal process a simple flattened blade, the apex a curved beak.

Male.—Length, about 6.5 millimeters; wing, 7.5.

Rostrum and palpi brownish black. Antennæ with the scape dull ochreous, the fusion segment fulvous; remainder of antennæ dark brown. Head grayish, more infuscated on posterior orbits.

Mesonotum dull fulvous, the scutellum and postnotum a little darker. Pleura and pleurotergite conspicuously brownish black. Halteres yellow, the knobs infuscated. Legs with the coxæ brownish yellow, brightened apically; trochanters yellow; femora yellow, with a broad dark brown subterminal ring, the ex-

treme apex bright yellow; tibiæ and tarsi light yellow. Wings (Plate 1, fig. 15) tinged with yellowish brown, the prearcular and costal regions clear yellow; a heavy brown pattern, the areas not bordered by paler; a series of alternating brown and yellow areas on costa to wing tip; the most conspicuous of the dark clouds are marginal at ends of all longitudinal veins, at origin of Rs and on the supernumerary crossvein in cell Cu; cord, outer end of cell 1st M_2 and fork of M_{1+2} conspicuously seamed with brown; veins dark brown, alternately yellow and brown in the costal region. Venation: Supernumerary crossveins and spurs in cell C relatively few in number, there being only one or two beyond the origin of Rs; m-cu at about two-thirds its length beyond the fork of M.

Abdominal tergites yellowish brown, margined laterally with darker brown; sternites clearer yellow; hypopygium brown. Male hypopygium (Plate 3, fig. 40) with the caudal margin of the tergite, 9t, produced into two slender glabrous spinous lobes that are separated by a broad U-shaped notch. Outer dististyle, *od*, broadest on basal half, the outer margin with abundant spinous points and tubercles to produce a crownlike appearance. Interbasal process, *i*, a flattened blade, relatively narrow, the apex a simple strongly curved beak, as figured.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 5, 1930, by sweeping (*Clagg*); holotype, male; Mount Apo, 7,000 to 8,000 feet, September 1 to 20, 1930 (*Clagg*); several paratypes, both sexes.

Epiphragma (*Polyphragma*) *fulvinota* bears a marked superficial resemblance to *E. (P.) ochrinota* Alexander (Luzon), but differs very conspicuously in the structure of the male hypopygium.

EPIPHRAGMA (POLYPHRAGMA) TRIARMATA sp. nov. Plate 1, fig. 16; Plate 3, fig. 41.

Male.—Length, about 7.5 to 8 millimeters; wing, 8.2 to 9.

Female.—Length, about 10 millimeters; wing, 9.

Generally similar in appearance to *E. (P.) ochrinota* Alexander, differing especially in the larger size and structure of the male hypopygium.

Antennal scape pale brown to brown, the fusion segment obscure fulvous. Head dull brown.

Mesonotum uniformly dull fulvous, the pleura abruptly dark brown; ventral sternopleurite paler. Halteres elongate, yellow, the knobs infuscated. Legs yellow, the darkened femoral ring

pale brown. Wings (Plate 1, fig. 16) grayish brown, the prearcular and costal regions light yellow; a heavy brown pattern that is conspicuously margined with pale yellow. Venation: Relatively numerous crossveins and spurs in cell C, including two or three beyond the origin of Rs.

Abdominal tergites brown, the basal sternites brighter, more yellowish, darkened laterally; hypopygium dark. Male hypopygium (Plate 3, fig. 41) with the ninth tergite, 9*t*, bearing two broad lobes that are separated by a V-shaped notch. Outer dististyle, *od*, curved to a simple chitinized hook. Inner dististyle angulated at midlength. Interbasal process, *i*, complicated in structure, at apex bearing three lobes, including a flattened paddlelike arm and a glabrous branch that terminates in an acute spine and a lower obtuse lobe.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 2 to 5, 1930 (*Clagg*); holotype, male; allotype, female; paratype, male. "Sweeping among ferns and on mossy trees."

ADELPHOMYIA CARBONICOLOR sp. nov. Plate 1, fig. 17.

General coloration of thorax shiny coal-black; wings with a grayish tinge, sparsely patterned with brown; Sc₁ long; R₂ at fork of R₃₊₄.

Male.—Length, about 4.5 millimeters; wing, 4.7.

Rostrum and palpi black. Antennæ black throughout. Head dull blackish gray.

Pronotum, mesonotum, and pleura shiny coal-black. Halteres yellow, the knobs dark brown. Legs with the fore coxæ pale brown, the remaining coxæ yellow; trochanters yellow; remainder of legs broken. Wings (Plate 1, fig. 17) with a grayish tinge, the costal third a little more cream-colored; a sparse brown pattern, including the stigma, a paler cloud at origin of Rs, a narrow seam on anterior cord, and weak gray clouds on posterior cord, outer end of cell 1st M₂, Sc₂, and as an arcular suffusion; veins pale, darker in the infuscated areas. Macrotrichia of cells relatively few. Venation: Sc₂ some distance from the tip of Sc₁; Rs angulated and weakly spurred at origin; R₂ at fork of R₃₊₄; cell M₁ small; m-cu from one-third to one-half its length beyond the fork of M.

Abdominal tergites black; sternites brownish black, the caudal margins of the intermediate segments a little paler; hypopygium dark.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,800 feet, July 3, 1930 (*Clagg*); holotype, male. "Among ferns and undergrowth along margins of small brook."

Adelphomyia carbonicolor is most closely related to *A. luzonensis* Alexander (Luzon), differing most evidently in the polished black thorax, and details of wing pattern and venation. The wings of the present species are noticeably wider, but this may well be a sexual character.

LIMNOPHILA (DICRANOPHRAGMA) RETRACTA sp. nov. Plate 1, fig. 18.

General coloration brownish gray, the thorax immaculate; antennal scape black, the basal flagellar segments pale brown; legs and halteres yellow; wings whitish, with a restricted brown pattern, the six dark costal areas narrow; supernumerary crossvein in cell R_3 more than twice its length from tip of vein R_3 .

Female.—Length, about 5.5 millimeters; wing, 4.8.

Rostrum and palpi black. Antennæ with the scapal segments black; basal flagellar segments pale brown, the outer segments passing into darker brown. Head dark, sparsely pruinose.

Mesonotum brownish gray, without markings, the posterior sclerites more blackish, sparsely pollinose. Pleura dark brown, sparsely pruinose. Halteres obscure yellow. Legs with the fore coxæ dark brown, the other coxæ paler; trochanters obscure yellow; remainder of legs yellow, the terminal tarsal segments darkened. Wings (Plate 1, fig. 18) whitish, the prearcular and costal regions very slightly more yellow; a relatively spare spotted brown pattern, including six relatively narrow costal blotches, the second at origin of R_s , the third at fork of Sc , the fourth at fork of R_1 , the two latter connected posteriorly to form a V-shaped area along the anterior cord, leaving a small whitish area in cell Sc_1 ; relatively large brown marginal spots at ends of all the longitudinal veins, these becoming progressively larger back from the wing tip; remainder of wing disk with small, chiefly circular or irregular areas in all cells, these not forming conspicuous transverse lines; veins pale, darker in the clouded areas. Venation: Sc_1 ending opposite the fork of R_{2+3+4} , Sc_2 about opposite midlength of the latter vein; supernumerary crossvein in cell R_3 more than twice its own length back from tip; cell M_1 about two-thirds its petiole; m-cu less than its own length beyond fork of M .

Abdomen dark brown; valves of ovipositor long and slender, the long tergal valves brown, paling to horn color at tips; sternal valves entirely dark, straight.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 2, 1930 (*Clagg*); holotype, female.

Limnophila (*Dicranophragma*) *retracta* is most closely related to *L. (D.) remota* (de Meijere), differing most evidently in the unmarked mesonotal præscutum and the more sparsely patterned wings.

LIMNOPHILA (DICRANOPHRAGMA) RADIALIS sp. nov.

General coloration of mesonotal præscutum light buffy gray, immaculate; wings whitish, the costal region light yellow; a very abundant brown pattern that is heavier and darker in the radial field; wing tip narrowly clear yellow; supernumerary crossvein in cell R_3 far from tip of vein R_3 .

Female.—Length, about 6 millimeters; wing, 5.5.

Rostrum and palpi black. Antennæ with the scapal segments black, the flagellum chiefly dark brown. Head dark gray.

Mesonotal præscutum light buffy gray, without markings; pseudosutural foveæ pale; posterior sclerites of mesonotum darker gray. Pleura dark, sparsely pruinose. Halteres light dusky, the knobs weakly infuscated. Legs with the coxæ yellow, the fore and middle coxæ a little darker and weakly pruinose; remainder of legs yellow, the tips of the tarsi weakly darkened. Wings with the ground color whitish, the costal region light yellow; a very abundant dotted and transversely streaked brown pattern that becomes conspicuously darker and heavier in the radial field, where the ground color is reduced to tiny spots and dots; the marginal areas at ends of medial and cubical veins ring-like, with pale centers; the areas in the cells are dots and spots that tend to flow together; in cells M, Cu, 1st A, and 2d A the areas are more elongate and transverse; dark areas in costal field reduced in number; wing tip in radial and medial fields narrowly clear light yellow; veins pale, somewhat darker in the infuscated areas. Venation; Supernumerary crossvein in cell R_3 about two and one-half times its length from tip of vein R_3 , the second section of this vein being about one-third longer than the basal section.

Abdomen dark brown.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 4, 1930, at trap lantern (*Clagg*); holotype, female; paratype, female.

Limnophila (*Dicranophragma*) *radialis* is allied to *L. (D.) retracta* sp. nov., but is sufficiently well distinguished by the characters outlined above.

ERIOPTERINI

GONOMYIA (LIOPHLEPS) PTILOSTENELLA sp. nov. Plate 1, fig. 19; Plate 3, fig. 42.

General coloration black, sparsely variegated with pale, including a longitudinal silvery white stripe on pleura; antennæ, halteres, and legs black; wings with a dusky tinge; Sc_1 ending opposite the origin of Rs, Sc_2 far from its tip; cell 2d M_2 small; m-cu far before the fork of M.

Male.—Length, about 2.5 millimeters; wing, 3.2.

Female.—Length, about 3 to 3.8 millimeters; wing, 3.5.

Rostrum very short, black, margined in front with paler; palpi black. Antennæ black throughout; flagellar segments oval; segments with a dense erect white pubescence and slightly longer, but inconspicuous verticils, the latter not greatly elongated in the male, as usual in *Lipophleps*. Head black, sparsely pruinose, the narrow orbits and anterior vertex pale.

Pronotum black; anterior lateral pretergites conspicuously light yellow, the narrow posterior lateral pretergites white. Mesonotal præscutum black, subnitidous; humeral triangles small, yellow; pseudosutural foveæ large, polished black; scutum black, with a small obscure yellow spot on either side of the midline behind the suture; scutellum broad, black, pruinose, postnotal mediotergite black, the cephalic portion with a broad pale yellow V-shaped area. Pleura black, pruinose, with a broad silvery white longitudinal stripe on the dorsal sternopleurite, becoming broader behind; posterior dorsal pleurites whitish. Halteres black. Legs black. Wings (Plate 1, fig. 19) with a dusky tinge; veins brownish black. Venation: Prearcular region notably developed in both sexes; Sc_1 ending opposite the origin of Rs, Sc_2 far from its tip, at near mid-distance between arculus and origin of Rs; cell 2d M_2 very small, from two-fifths to one-third its petiole; m-cu about its own length before the fork of M.

Abdomen black, the pleural membrane yellow; hypopygium brownish yellow. Male hypopygium (Plate 3, fig. 42) with the ninth tergite, 9t, large, the caudal margin with a conspicuous V-shaped median notch, the broad lobes thus formed truncate or nearly so. Basistyle, *b*, produced caudad into a stout lateral and an equally long but more slender mesal lobe, both conspicuously setiferous. Two dististyles, *d*, borne in the notch of the

basistyle, the outer a pale glabrous rod that is sinuously narrowed to an acute point; inner style subequal or longer, pale, divided at tip into two broad pale blades; at midlength of the style with numerous delicate erect setulæ. Ovipositor with the tergal valves black, the hairy sternal valves paler.

LUZON, Tayabas Province, Candelaria, altitude 50 meters, June 21, 1930, in small ferns at side of stream (*McGregor and Rivera*); holotype, male; allotype, female; paratypes, 2 females.

Gonomyia (*Lipophleps*) *ptilostenella* is most closely related to *G. (L.) ptilostenoides* Alexander (Formosa), differing conspicuously in the coloration and details of venation, such as the developed prearcular region. The discovery of the male sex of the present species shows that this group of crane flies is to be retained in *Lipophleps* for convenience only, since the genitalic and antennal structure of the male is much more like that found in *Progonomyia* and *Ptilostena* than in *Lipophleps*. It seems possible that a new subgeneric group, near *Ptilostena*, might prove necessary to receive this species and allies.

GONOMYIA (LIPOPHLEPS) ACANTHOPHALLUS sp. nov. Plate 1, fig. 20; Plate 3, fig. 43.

General coloration dark brown; head gray; scutellum obscure yellow, dark at base; legs black; wings brownish yellow, the stigma a trifle darker; Sc long; male hypopygium with the dististyle single, subterminal in position; phallosome very large and complex, the largest lobe fan-shaped, with a row of spines down the face.

Male.—Length, about 3.3 millimeters; wing, 3.8 to 4.

Rostrum brownish yellow; palpi black. Antennæ black throughout. Head dark gray, the occiput restrictedly paler.

Mesonotal præscutum and scutal lobes dark brown, the anterior lateral pretergites light yellow; median region of scutum and scutellum obscure yellow, the base of the latter dark brown; postnotal mediotergite dark brown, with a yellow area on cephalic lateral portion. Pleura dark brown, with a broad silvery white longitudinal stripe; pteropleurite light yellow. Halteres dusky, the knobs obscure yellow. Legs with the fore and middle coxæ brown, the posterior coxæ a little paler; trochanters pale; remainder of legs black, the femoral bases a little paler. Wings (Plate 1, fig. 20) brownish yellow, the stigmal region a trifle darker but very diffuse; veins brown. Venation: Sc long, Sc₁ ending about opposite one-third the length of the long Rs, Sc₂ a short distance from its tip; branches of Rs long; cell 1st M₂ closed; m-cu at fork of M.

Abdominal tergites dark brown, the sternites obscure yellow. Male hypopygium (Plate 3, fig. 43) with the basistyles, *b*, stout, the outer lateral angle produced into a cylindrical fleshy setiferous lobe. Dististyle, *d*, single, a trifle longer than the lobe of the basistyle, entirely pale, slightly expanded and angularly bent at about three-fourths the length, terminating in a fasciculate seta. Phallosome, *p*, large and complex, terminating in three lobes, one short and obtuse, entirely glabrous; another a long straight rod; the third a broadly expanded, fan-shaped structure, down the face of which extends a row of recurved spines that gradually decrease in size toward the base.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 3 to 5, 1930, by sweeping (*Clagg*); holotype, male; paratype, 1 alcoholic male.

Gonomyia (*Lipophleps*) *acanthophallus* is very different from the other described *Lipophleps* with long subcosta. It is closest to *G. (L.) longiradialis* Alexander (Luzon) in the structure of the basistyle and dististyle of the male hypopygium, but differs very notably in the details of the phallosome.

Genus ERIOPTERA Meigen

ERIOPTERA PERPICTULA sp. nov. Plate 1, fig. 21; Plate 3, fig. 44.

General coloration of mesonotal præscutum and scutum reddish brown; posterior sclerites of mesonotum dark brown; pleura variegated dark and pale brown; halteres pale yellow; wings cream yellow, with a handsome brown pattern.

Male.—Length, about 3.2 millimeters; wing, 4.

Rostrum brown; palpi dark brown. Antennæ short, the segments with long, conspicuous verticils. Head pale ochereous.

Pronotum and anterior lateral pretergites chiefly white. Mesonotal præscutum pale reddish brown, the humeral region more whitish yellow; scutal lobes reddish brown; scutellum and postnotum brownish black. Pleura variegated longitudinally with dark brown and obscure brownish yellow. Halteres pale yellow. Legs with the fore and middle coxæ dark brown, the posterior coxæ paler; trochanters yellow; remainder of legs broken. Wings (Plate 1, fig. 21) cream yellow, with a handsome brown pattern, distributed as follows: Arcular region; a large area at origin of Rs, extending from Sc to M; a broad oblique cross-band along the cord, extending from the stigmal region to Cu, wider in the radial field, narrowly interrupted at the fork of M; outer end of cell 1st M₂; marginal spots on veins R_s, M_s, M₄, Cu₁, and 2d A; conspicuous grayish brown clouds in the

basal portions of cells M and Cu and the central portion of cell 1st A; veins pale yellow, darker in the infuscated areas. Macrotrichia of veins and marginal fringes very easily broken, leaving microscopic peglike spines. Venation: Sc_1 very long, Sc_2 being just beyond the origin of Rs; Rs subequal to R_{3+4} ; R_{2+3} subperpendicular; R_{2+3+4} in alignment with R_4 ; cell 1st M_2 symmetrically closed; m-cu at fork of M; tips of veins M_3 , M_4 , and Cu_1 deflected very slightly toward wing tip; vein 2d A straight.

Abdominal tergites dark brown, the sternites somewhat paler; hypopygium yellow. Male hypopygium (Plate 3, fig. 44) with the basistyle, *b*, very long and slender. Dististyles two, terminal in position, the outer, *od*, a long straight or gently sinuous blackened rod, at apex a little dilated and set with blunt tubercles. Inner dististyle a slightly shorter pale blade, slightly dilated at distal end. Gonapophyses appearing as simple black spines. *Ædeagus*, *a*, strongly curved.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,800 feet, July 3, 1930 (*Clagg*); holotype, male. "Among ferns and undergrowth along margins of small brook." Mount Apo, Bakraeyon, altitude 8,000 feet, dancing over a rotten log, September 15, 1930 (*Clagg*); paratypes, 15 of both sexes.

I am undecided as to the strict systematic position of this fly and for the present, at least, would place it in *Erioptera*. The essential characters of the fly do not seriously disagree with those of *Erioptera*, although the meral region is somewhat less developed than in most of the subgeneric groups.

TOXORHINA (TOXORHINA) DENDROIDEA sp. nov. Plate 1, fig. 22; Plate 3, fig. 45.

Size small (wing, male, 4.2 millimeters); mesonotum brownish ocherous, more grayish behind, unmarked; wings with cell M_2 open by atrophy of m; male hypopygium with a dense area of dendroidal setæ on mesal face of basistyle; outer dististyle bifid; branches of *ædeagus* short.

Male.—Length (excluding rostrum), about 3.8 millimeters; wing, 4.2.

Rostrum brown, the apex broken in the unique type. Antennæ black. Head gray; eyes (male) very large, broadly contiguous beneath.

Mesonotal præscutum and scutal lobes brownish ocherous, without markings; median area of scutum, base of scutellum and postnotal mediotergite light gray; posterior margin of scutellum ocherous. Pleura ocherous, sparsely pruinose. Legs with the coxæ and trochanters yellow; remainder of legs black.

Wings (Plate 1, fig. 22) hyaline; veins dark brown. Macrotrichia on all longitudinal veins beyond cord, on entire length of Rs, on distal half of M, and distal eighth of basal section of Cu₁. Venation: Sc₁ ending a short distance beyond origin of Rs, Sc₂ a corresponding distance before this origin; cell M₂ open by atrophy of m; m-cu at fork of M, about one-third longer than the distal section of Cu₁.

Abdomen brownish ochereous. Male hypopygium (Plate 3, fig. 45) with the basistyles, *b*, having the mesal face densely set with setigerous punctures, the majority of which bear remarkable branched spinous setæ of many forms (Plate 3, fig. 45, *ds*, sub). Outer dististyle, *od*, bifid, the outer arm a slender, acutely pointed blade, the inner arm stouter, straight, its obtuse apex narrowly blackened. Inner dististyle a broad pale blade, at near midlength on outer margin with a blunt tubercle that bears about a dozen spines; apex of style obtusely rounded. Branches of ædeagus, *a*, short.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 2, 1930 (*Clagg*); holotype, male. "Among ferns and undergrowth along margins of small brook." Mount Apo, 8,000 feet, September 19, 1930 (*Clagg*); paratypes, males.

Toxorhina (*Toxorhina*) *dendroidea* is most closely allied to *T. (T.) duyagi* Alexander, *T. (T.) montina* Alexander, and *T. (T.) biceps* Alexander, all of Luzon, differing conspicuously in the structure of the male hypopygium. The rather remarkable group of branched setæ on the mesal face of the basistyle is not found in the three related species listed above.

ILLUSTRATIONS

[Legend: *a*, ædeagus; *b*, basistyle; *d*, dististyles; *ds*, dendroidal seta; *g*, gonapophysis; *i*, interbasal process; *id*, inner dististyle; *od*, outer dististyle; *p*, phallosome; *s*, sternite; *t*, tergite; *vd*, ventral dististyle.]

PLATE 1

- FIG. 1. *Scamboneura mindanaoensis* sp. nov., wing.
 2. *Dolichopeza (Nesopeza) spinisternata* sp. nov., wing.
 3. *Limonia (Limonia) claggi* sp. nov., wing.
 4. *Limonia (Limonia) synchæta* sp. nov., wing.
 5. *Limonia (Limonia) pleiades* sp. nov., wing.
 6. *Limonia (Limonia) pronotalis* sp. nov., wing.
 7. *Limonia (Limonia) cynotis* sp. nov., wing.
 8. *Limonia (Limonia) prolixicornis* sp. nov., wing.
 9. *Limonia (Limonia) pilosicaudata* sp. nov., wing.
 10. *Limonia (Limonia) davaoensis* sp. nov., wing.
 11. *Limonia (Limonia) calianensis* sp. nov., wing.
 12. *Limonia (Libnotes) bellula* sp. nov., wing.
 13. *Helius (Helius) trianguliferus* sp. nov., wing.
 14. *Epiphragma (Polyphragma) fuscinota* sp. nov., wing.
 15. *Epiphragma (Polyphragma) fulvinota* sp. nov., wing.
 16. *Epiphragma (Polyphragma) triarmata* sp. nov., wing.
 17. *Adelphomyia carbonicolor* sp. nov., wing.
 18. *Limnophila (Dicranophragma) retracta* sp. nov., wing.
 19. *Gonomyia (Lipophleps) ptilostenella* sp. nov., wing.
 20. *Gonomyia (Lipophleps) acanthophallus* sp. nov., wing.
 21. *Erioptera perpictula* sp. nov., wing.
 22. *Toxorhina (Toxorhina) dendroidea* sp. nov., wing.

PLATE 2

- FIG. 23. *Scamboneura mindanaoensis* sp. nov., male hypopygium, details.
 24. *Scamboneura davaoensis* sp. nov., male hypopygium, ninth tergite.
 25. *Scamboneura davaoensis* sp. nov., male hypopygium, dististyles.
 26. *Scamboneura davaoensis* sp. nov., male hypopygium, appendage of ninth sternite.
 27. *Dolichopeza (Nesopeza) spinisternata* sp. nov., male hypopygium.
 28. *Dolichopeza (Nesopeza) paucispinosa* sp. nov., male hypopygium.
 29. *Limonia (Limonia) claggi* sp. nov., male hypopygium.
 30. *Limonia (Limonia) synchæta* sp. nov., male hypopygium.
 31. *Limonia (Limonia) pleiades* sp. nov., male hypopygium.
 32. *Limonia (Limonia) cynotis* sp. nov., male hypopygium.
 33. *Limonia (Limonia) prolixicornis* sp. nov., male hypopygium.
 34. *Limonia (Limonia) pilosicaudata* sp. nov., male hypopygium.
 35. *Limonia (Limonia) pilosicaudata* sp. nov., male hypopygium, ninth tergite.

PLATE 3

- FIG. 36. *Limonia* (*Limonia*) *davaoensis* sp. nov., male hypopygium.
37. *Limonia* (*Limonia*) *calianensis* sp. nov., male hypopygium.
38. *Limonia* (*Libnotes*) *bellula* sp. nov., male hypopygium.
39. *Epiphragma* (*Polyphragma*) *fuscinota* sp. nov., male hypopygium.
40. *Epiphragma* (*Polyphragma*) *fulvinota* sp. nov., male hypopygium.
41. *Epiphragma* (*Polyphragma*) *triarmata* sp. nov., male hypopygium.
42. *Gonomyia* (*Lipophleps*) *ptilostenella* sp. nov., male hypopygium.
43. *Gonomyia* (*Lipophleps*) *acanthophallus* sp. nov., male hypopygium.
44. *Erioptera* *perpictula* sp. nov., male hypopygium.
45. *Toxorhina* (*Toxorhina*) *dendroidea* sp. nov., male hypopygium.

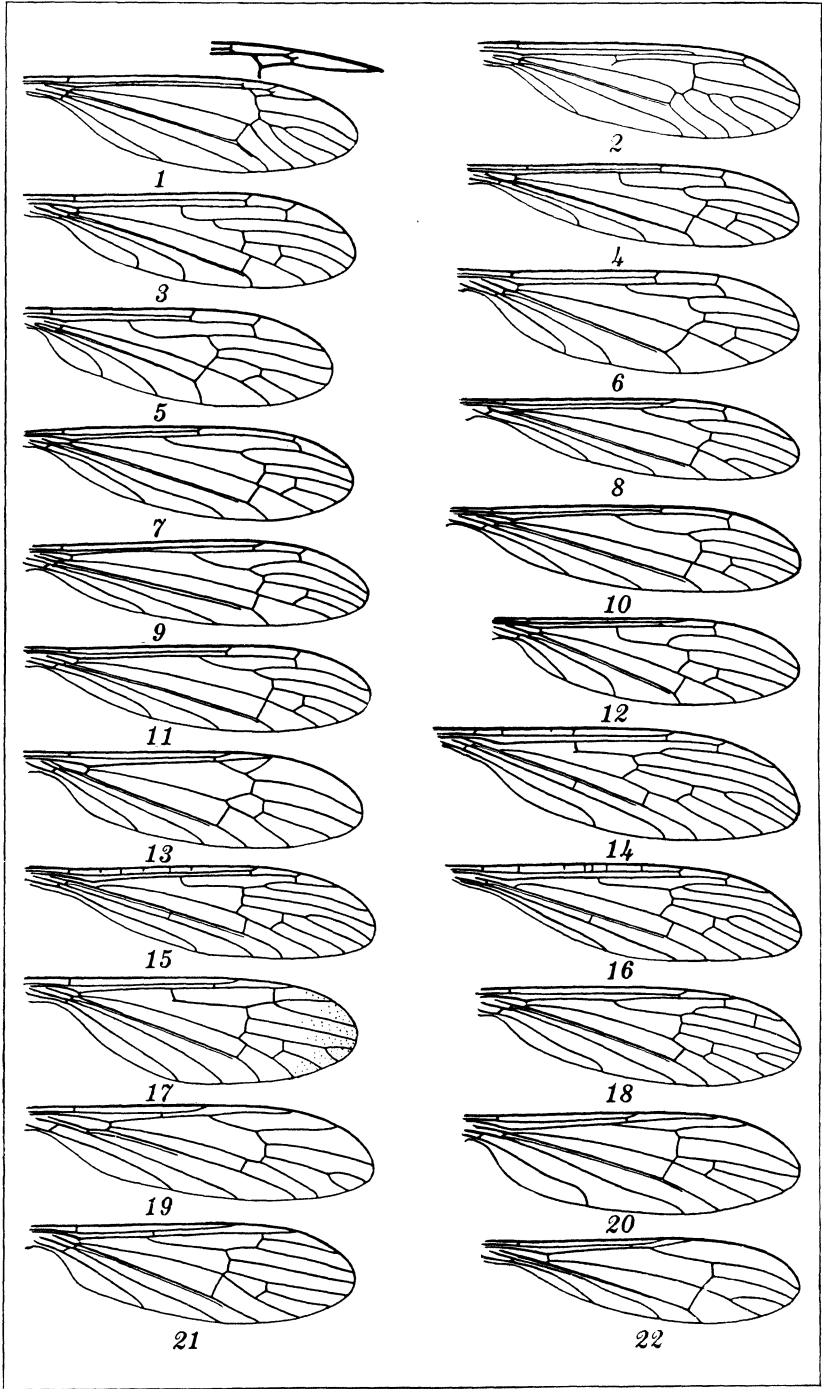


PLATE 1.

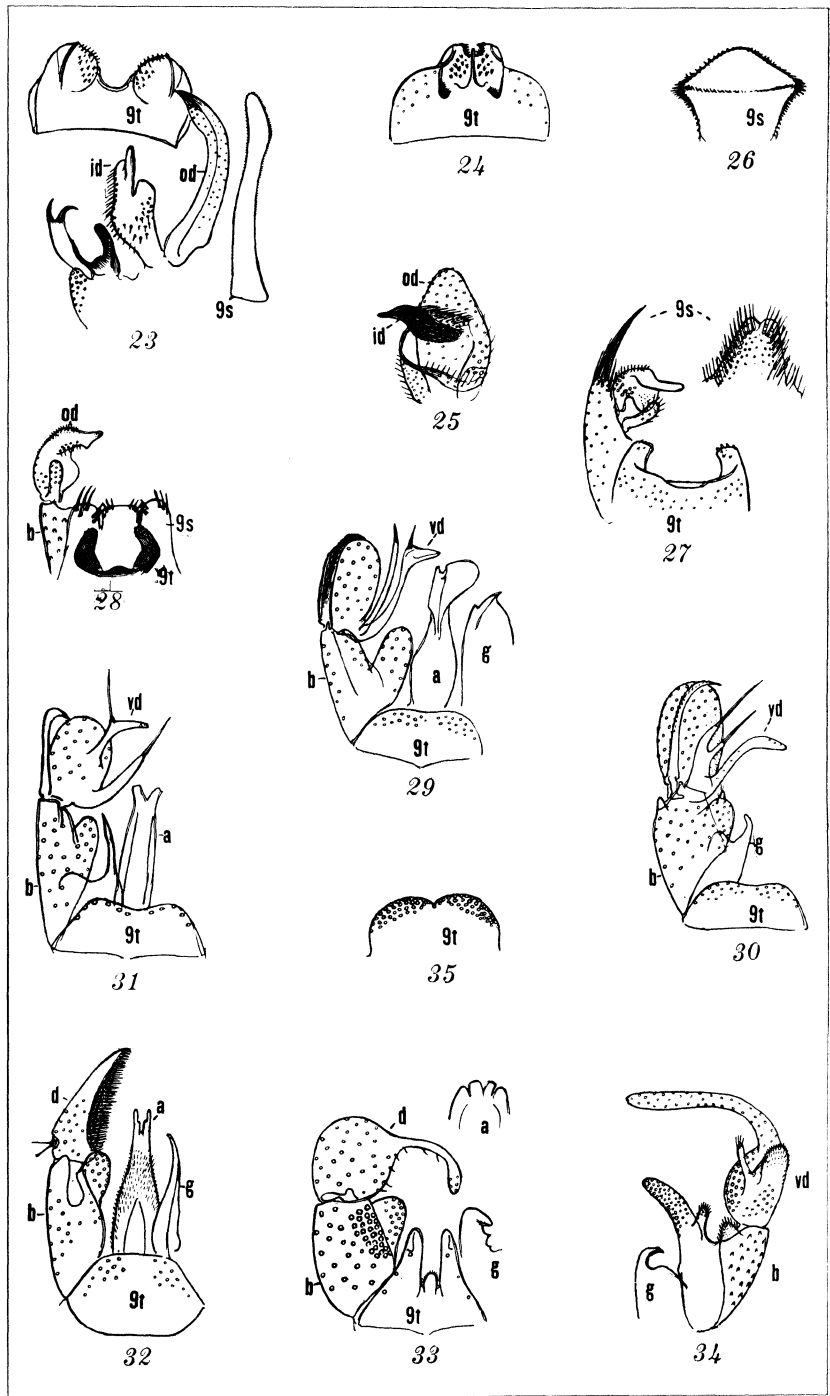
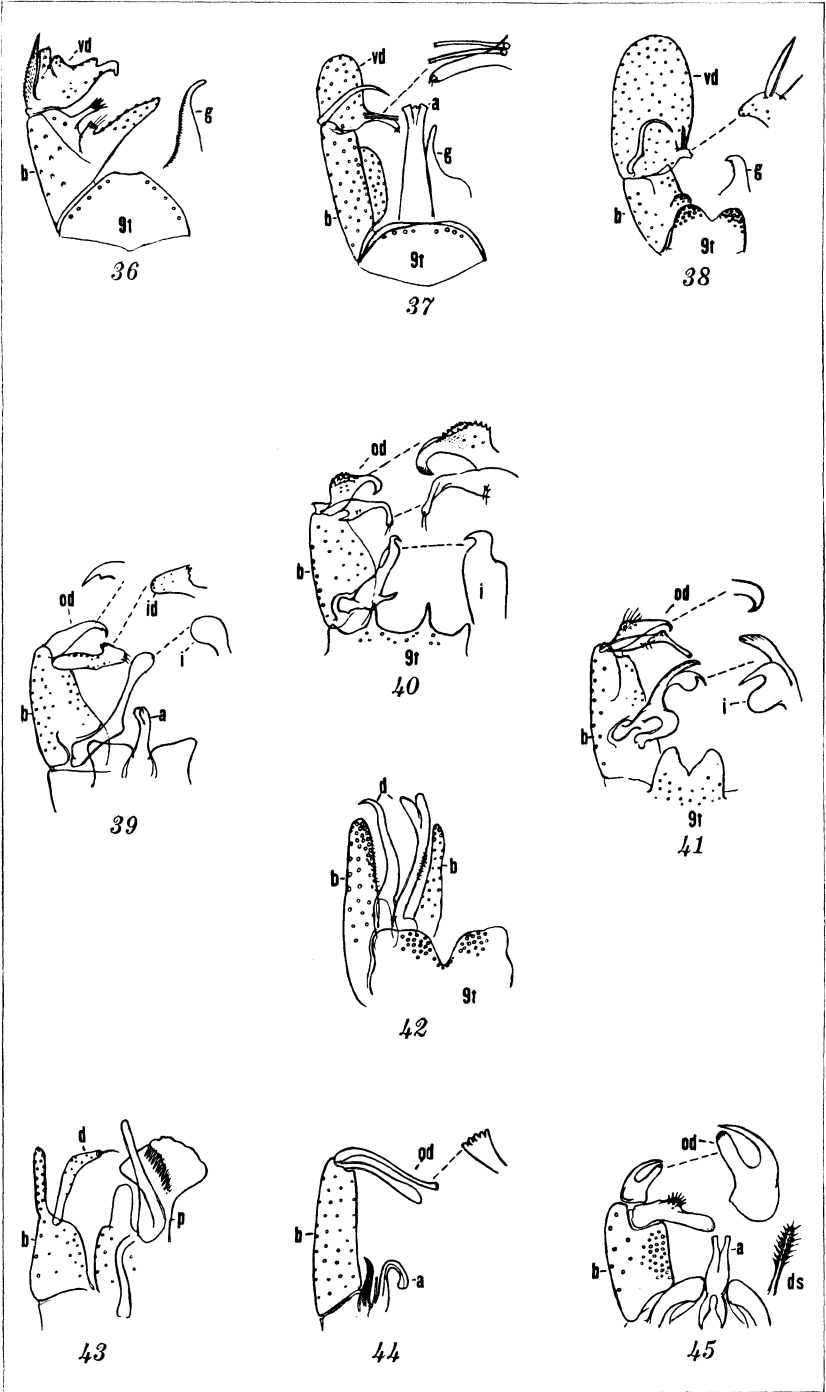


PLATE 2.



MORPHOLOGY OF THE MALE FLOWER OF *COCOS* *NUCIFERA* LINNÆUS¹

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THREE PLATES

INTRODUCTION

The coco palm, which is one of the most important crop plants of the Philippines, has been the subject of morphological and agronomical investigations. While the morphological study of the coco palm has had a very interesting beginning, a great deal still remains to be done. The present paper is intended to give an account of the organography of the male flower as well as the morphology of the microsporangium and the microspore. Although the results herein presented may not show wide divergence from the sequence usually found among monocotyledonous plants, they certainly are of value in pointing out variation within a given group.

A recent morphological and cytological work on *Cocos nucifera* is that by Juliano(6) who described and figured the development of the inflorescence, the female flower, and the stony layer. This work was followed by an account of the development of its megasporangium and megagametophyte by Quisumbing and Juliano.(8)

While working on extensive experiments on the germination and viability of the microspores of the coco palm, Aldaba(1) observed that the majority of the male flowers begin to open at about 6 o'clock and dehisce at about 8 o'clock in the morning. The microspores germinated in 5 to 30 per cent sugar solution, and remained viable from two to nine days after they were dehisced. Recently, Santos(10) wrote an account of the reduction division of the microspore mother cell and reported that the coco palm has sixteen bivalent chromosomes that split

¹ Experiment-station contribution No. 715.

lengthwise at the same time. The daughter nuclei resulting from the first division do not pass into anything resembling the typical resting condition but soon reorganize and prepare for the homotypic division. So far as the writers are aware, no work has been done on the morphology of the male flower except the studies noted above.

MATERIALS AND METHODS

Most of the material was collected from October to November, 1926,² from the Bacomo coconut plantation, College of Agriculture, Los Baños, and was killed and fixed in the field and in the laboratory. Microspore material was gathered from trees in the coconut grove adjoining the college campus, in October, 1930. Several killing agents were tried, among which were chromo-acetic stock, formalin-acetic-alcohol,⁽²⁾ and warm corrosive sublimate. The first two killing agents proved to be very satisfactory for our purpose. The material was embedded in paraffin in the usual fashion and sections were cut 7 to 10 microns in thickness. Most of the preparations were stained in Haidenhain's iron-hæmatoxylin and counterstained with orange gold dissolved in clove oil, while Flemming's triple stain and safranin-light green combination were utilized also to advantage.

MALE FLOWER

The male flower is borne either singly or in groups of two or three in the axil of each tertiary bract on the rachillæ (lateral branches) of the inflorescence. This tertiary bract is a tiny collarlike structure subtending the male as well as the female flowers. Often the male flower is intermixed with the female flower in the axil of the basal tertiary bract. The individual male flower is sessile, and can be easily distinguished from the basal female flower by its size and position, and it usually matures first. It is very much smaller than the female flower, ranging from 1 to 2.5 centimeters in length, and 0.3 to 0.6 centimeter in breadth. It is unsymmetrical in shape and pronouncedly angular in transverse section (Plate 2, fig. 8). It possesses six floral envelopes, the morphology of which has

² Delay in the preparation of this manuscript for publication was due to the appointment of the junior author as a Fellow of the National Research Council of America from 1926 to 1928, and severance of his connection with the College of Agriculture upon his return to the Islands in 1928. In that year the senior author was appointed a Fellow of the University of the Philippines, and studied abroad from 1928 to 1930.

been worked out by Möbius.(7) The three outer perianth segments, the sepals, are small, valvate, and triangular. They alternate with the three inner perianth segments, the petals, which are oblong and acute. The edges of the petals fit together up to the opening of the flower. Inclosed by these six perianth envelopes, the sepals and the petals, are the six stamens which form a single whorl, one opposite each perianth segment. The stamens are hypogynous and free. The anthers are 4-celled, dorsifixed after dehiscence, elongated, introrse, and provided with vertical dehiscence. The filament is rather stout and cylindrical. At the summit of the receptacle is located a tricarpedal rudimentary pistil with its styles and stigmas distinctly separate. In very few cases(3, 4) the abortive pistil has been observed to become functional, and is rarely absent.(3)

The inflorescence of the coco palm, the development of which has been traced by Juliano,(6) "begins as a protuberance at the axil of the petiole, at the base of which two primary bracts, the outer and inner spathes, respectively, are cut off, the latter outgrowing the former as the inflorescence develops. The main axis, rachis, then cuts off the secondary bracts, at the axils of which primordia of the rachillae (lateral branches) develop. The rachillae, similar to the main axis (rachis), cuts off bracts (tertiary bracts) at the axils of which the flowers arise." Like the female flower, the individual male flower begins its ontogenetic development as an emergence or papillate outgrowth(*p*) in the axil of the tertiary bract (*tb*) of the rachillae (Plate 1, fig. 1). The female and male floral primordia cannot easily be distinguished from each other at this stage. However, most of the floral primordia are males and only a few of the basal ones ever develop into female flowers. The axillary floral primordium then enlarges and later assumes a conical shape. The first floral organs of the male flower to differentiate at the base of the floral primordium are the three sepals (*s*), which appear simultaneously as papillate protrusions (Plate 1, fig. 2). These soon elongate, bend, and cover the apex of the primordium (Plate 1, fig. 3). As soon as the three sepals have developed, the petals (*pt*) arise simultaneously as small papillate humps within the whorl of sepals, and alternating with the latter (Plate 1, fig. 4). They also elongate, pushing their way between the sepals and the floral cone. These cover the apex of the primordium, and later fuse at their margins (Plate 1, fig. 7). These petals are inclosed by the sepals at their juvenile stage, but as the flower enlarges and matures, the petals outgrow the sepals

(Plate 2, fig. 8). This condition is the reverse of that found by the senior author(6) in the female flower where the petals never outgrow the sepals. Within the petals (Plate 1, fig. 5) are formed the six stamens (*st*) which differentiate as small humps after the petals have been fully formed, and these early differentiate into anthers and filaments (Plate 1, fig. 7). The last floral organ to develop is the rudimentary tricarpeled pistil (*c*) with its style and stigma distinctly separate (Plate 1, fig. 6). In other words, the development of the floral organs of the male flower is acropetal, and they arise as follows: sepals, petals, stamens, and carpels. This development of the floral organs is similar to that found by the senior author(6) in the female flower and gives us additional evidence in favor of the view taken by Furtado(4) in which the papery ring (aril) subtending the pistil in the female flower is considered as a modified andrœcium.

MICROSPORANGE

Transversally, the microsporangium at its juvenile stage is nearly triangular in shape, and is composed of a mass of homogeneous isodiametric meristematic cells delimited by an epidermis. Very early it becomes faintly four-lobed (Plate 2, fig. 9) in cross-section and a formation of a vascular strand (*vb*) of the connective becomes apparent. Under the lobes and simultaneous with their appearance, there is the differentiation of a plate of four to six hypodermal cells (Plate 2, fig. 9a) which functions as the archesporium (*ar*). These hypodermal cells can be easily distinguished from the neighboring cells by their conspicuous size, their radial elongation, their large nuclei, and their greater affinity for stains. They form a single row of cells equaling the extent of the length of the anther. These radially elongated archesporial cells all divide almost simultaneously (Plate 2, fig. 10) by periclinal walls forming an outer layer, the primary parietal cells (*pp*), and an inner layer, the primary sporogenous cells (*psp*). By subsequent periclinal divisions of the primary parietal cells, definite concentric parietal tissue is formed (Plate 2, fig. 11 and 12), which may consist of six to eight layers of cells. The outermost layer (*en*) of the parietal tissue early enlarges in both directions, but more so towards the radial side, and forms a distinct layer before the maturation division stage (Plate 2, fig. 13). The inner parietal layers tangentially elongate and become laterally compressed, and this feature becomes more exaggerated and reaches its maximum as the anther matures, especially at the time the microspores are

formed (Plate 2, fig. 14). The two to four innermost layers of the parietal tissue which surround the sporogenous cells (Plate 2, fig. 13) function as the tapetum (*t*), the disorganization of which is concomitant with the microspore mother-cell stage. In this species the authors have not been able to observe a case where the tapetal cells ever become multinucleate as in *Typha*,⁽¹¹⁾ and hence resembles that found in *Eichornia* and *Pontederia*.⁽¹⁴⁾ At the end of the tetrad formation the tapetal cells have fully disorganized and the outer layer of the parietal tissue shows a very peculiar thickening (Plate 2, fig. 14), a feature of the endothecium (*en*).

The development of the parietal tissue is so rapid that the primary sporogenous cells which are at first near the epidermis of the microsporangium, become deeply embedded within it (Plate 2, fig. 11). These primary sporogenous cells directly by division produce the microspore mother cells of about eight to twelve in cross section. These cells are more or less polygonal in outline and fit tightly together. Their cytoplasm is dense, and their nuclei comparatively large, somewhat spherical with well-defined nuclear membrane. About the time the tapetum shows sign of disintegration, the microspore mother cells (Plate 3, fig. 15) and their nuclei enlarge and greatly differentiate from the adjoining parietal cells (Plate 2, fig. 13). This growth is accompanied by the rounding of the cells, separation from one another, and thickening of their walls (Plate 3, fig. 16). The chromatin assumes a beaded structure and then passes into the synaptic stage, which has been frequently described in microspore mother cells.

The subsequent divisions of the microspore mother cells have been described by Santos,⁽¹⁰⁾ so that any attempt to redescribe them would be superfluous. The main interesting point that we desire to emphasize here is the fact that not all the microspores derived from the divisions of the microspore mother cells become functional. In transverse sections of nearly mature anthers, one may find one of the microspores (tetrad) exhibiting a very distinct nucleus (Plate 3, fig. 20), in others only two (Plate 3, fig. 21), while in the rest there are three (Plate 3, fig. 22). If microspores that are being dehiscent are examined in water, some of them are apt to be found devoid of granular contents and therefore sterile. These sterile microspores never become spherical in water, and their longitudinal sutures persist. They are usually much smaller than the fertile microspores. A very interesting formation of the microspores has

been reported by Juel(5) in *Carex acuta* where the cell plate which is formed at early divisions is soon reabsorbed, three of the nuclei degenerate, and only the fourth nucleus remains functional.

The division of the microspore mother cell is simultaneous as shown in Plate 3, figs. 17 to 19, and reported by Santos.(10) In a majority of the investigated genera belonging to the same family, the division of the microspore mother cell is also simultaneous, as is true in *Chamaedorea sartorii*, *Ch. glaucophylla*, and *Ch. karwinskiana*,(15) *Chamaedorea corallina*, *Areca triandra*, *Caryota* sp., and *Pterygospermum* sp.(12) In *Nipa fruticans* Radermacher(9) reports that the microspore mother cell forms a dyad which divides to form the tetrad. Sometimes only one of the dyads divides so that three to four microspores are formed in a row (linear). After a short period of adherence in tetrads the microspores round off and acquire their coats. They are spherical and smooth. When dry they are ellipsoid and possess a single meridional groove or suture.

While the microspores are yet within the microsporangium, nuclear division takes place which gives rise to the tube nucleus (*t'*) and a generative cell (*g*) (Plate 3, fig. 24). In this condition, as is true of *Sarracenia purpurea*(13) and other species, the microspores are shed. The generative cell is lenticular in shape, and its elongated and oblong nucleus stains heavily, possessing denser and less regular chromatin. The tube nucleus is very much larger than the generative cell, and possesses a scanty chromatin network and large nucleolus.

SUMMARY

In *Cocos nucifera* the development of the floral primordia of the male flower is concomitant with that of the female flower. Most of the floral primordia developed on the rachillæ (lateral branches) of the rachis (main axis) become male flowers and only a few of the basal ones, female flowers.

The organs of the male flower arise in acropetal succession; namely, sepals, petals, stamens, and carpels.

The stamen early differentiates the microsporangium and the filament. Simultaneous with the formation of the lobes of the microsporangium, a plate of a single row of four to six archesporial cells is formed, and these cells divide periclinally forming the primary parietal layer and the primary sporogenous cells.

The primary parietal layer gives rise to six to eight layers of parietal cells, the outer layer of which becomes the endothecium, while the two to four innermost layers function as the

tapetum. No multinucleate tapetal cells have been observed in *Cocos nucifera*. The intermediate layers of cells may persist in the mature anther.

By subsequent divisions the primary sporogenous cells give rise to the microspore mother cells which divide simultaneously as is generally true of many of the investigated genera of palms. Not all of the microspores (tetrad) become functional.

Division of the microspore nucleus takes place within the microsporangium and the microspore is shed containing a tube nucleus and a lenticular generative cell.

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ILLUSTRATIONS

PLATE 1. *COCOS NUCIFERA* LINNÆUS

- FIG. 1. A longitudinal section of a portion of a rachilla showing male floral primordia (*p*); $\times 53$.
2. Longitudinal section of a male flower showing the beginning of the sepal (*s*); $\times 53$.
3. Longitudinal section of a male flower with the three sepals (*s*) already developed; $\times 53$.
4. Longitudinal section of an older male flower showing the beginnings of the petals (*pt*); $\times 53$.
5. Longitudinal section of a much older male flower showing the sepals (*s*) and petals (*pt*) already developed, and the beginning of the stamens (*st*); $\times 53$.
6. Portion of a longitudinal section of a male flower showing the stamens (*st*) and carpels (*c*) developing; $\times 53$.
7. Longitudinal section of a male flower showing all its parts already formed; $\times 53$.

PLATE 2. *COCOS NUCIFERA* LINNÆUS

- FIG. 8. Lateral view of an unopened mature male flower showing its perianth segments; $\times 6$.
9. Diagram of a transverse section of a young anther showing lobation and vascular bundle (*vb*) to the connective; $\times 66$. 9*a*, portion taken from fig. 9 showing the plate of archesporial cells (*ar*); $\times 706$.
10. Division of the archesporial cells to form the primary parietal cells (*pp*) and the primary sporogenous cells (*psp*); $\times 706$.
11. Portion of the anther showing the thick parietal tissue, the sporogenous cells (*sp*), and the tapetum (*t*); $\times 326$.
12. Longitudinal section of a young anther showing sporogenous cells (*sp*) and the parietal tissue to the right; $\times 706$.
13. Portion of a transverse section of an anther showing the parietal tissue, microspore mother cells (*mimc*), and the disintegrating tapetum (*t*); $\times 593$.
14. Transverse section of a mature anther before dehiscence, showing the microspores (*mi*), endothecium (*en*), stromium (*st'*), and portion of the remains of the intermediate cells of the parietal tissue; $\times 156$.

PLATE 3. *COCOS NUCIFERA* LINNÆUS

- FIG. 15. Microspore mother cell in resting condition; $\times 706$.
16. Microspore mother cell in diakenetic stage; $\times 706$.
17. Microspore mother cell in heterotypic telophase; $\times 706$.
18. Homotypic metaphase; $\times 706$.

FIG. 19. Homotypic metaphase; $\times 706$.

20. Tetrad showing only one of the microspores possessing distinct nucleus; $\times 706$.
21. Tetrad, only one of the microspores devoid of a nucleus; $\times 706$.
22. Tetrad, all microspores functional; $\times 706$.
23. Microspore before dehiscence showing distinct entire and exine; $\times 706$.
24. Longitudinal section of the microspore at shedding stage; note the tube nucleus (*t'*) and the lenticular generative cell (*g*); $\times 706$.

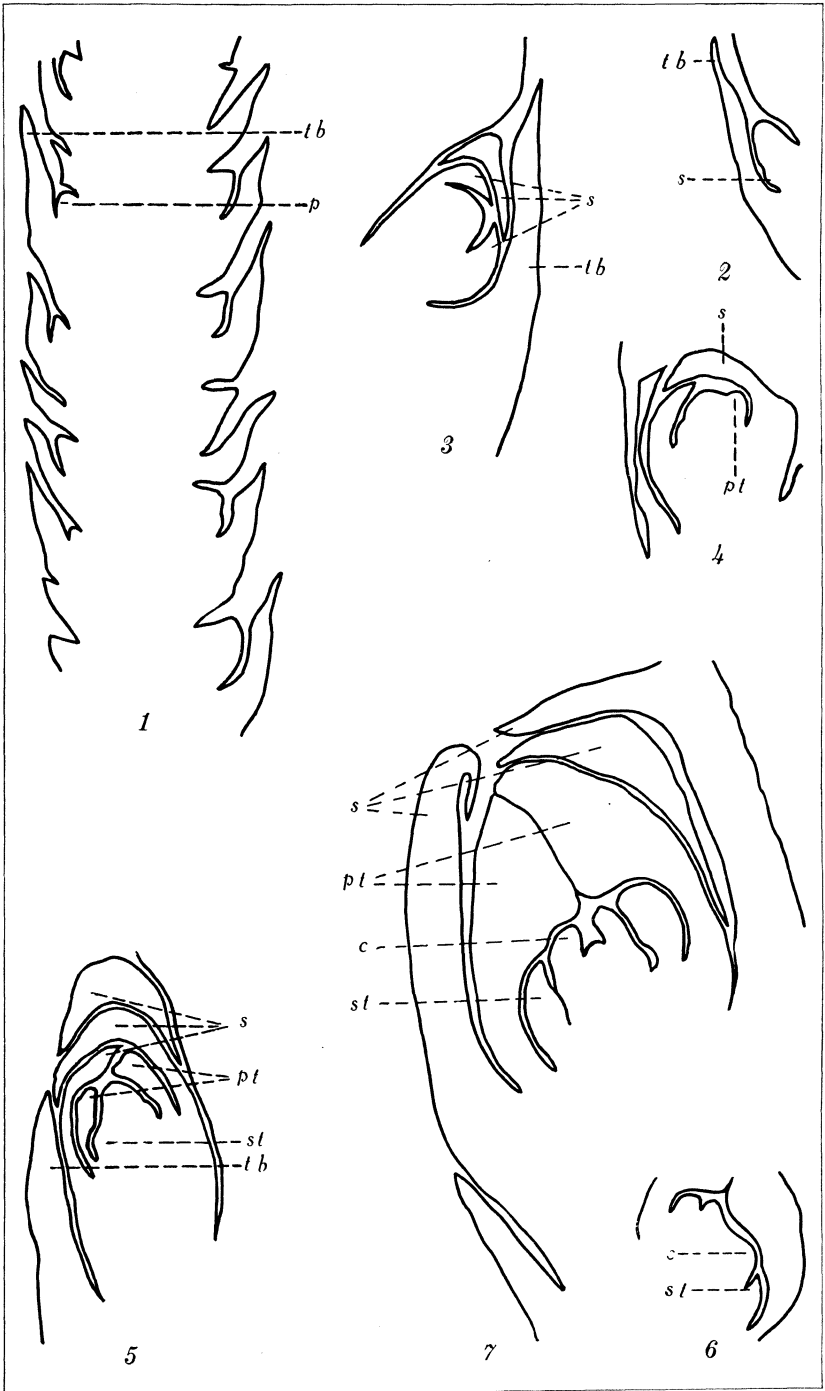


PLATE 1.

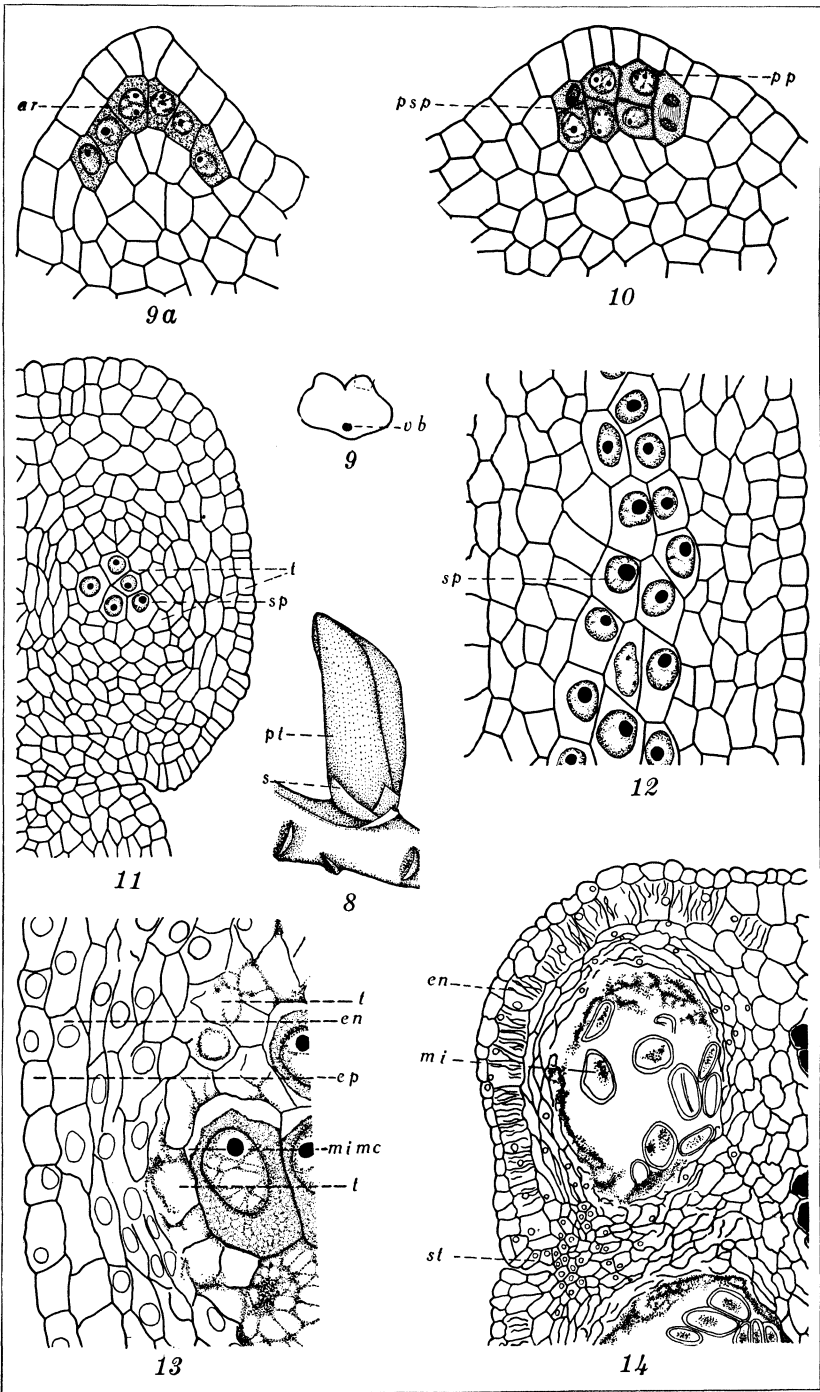


PLATE 2.

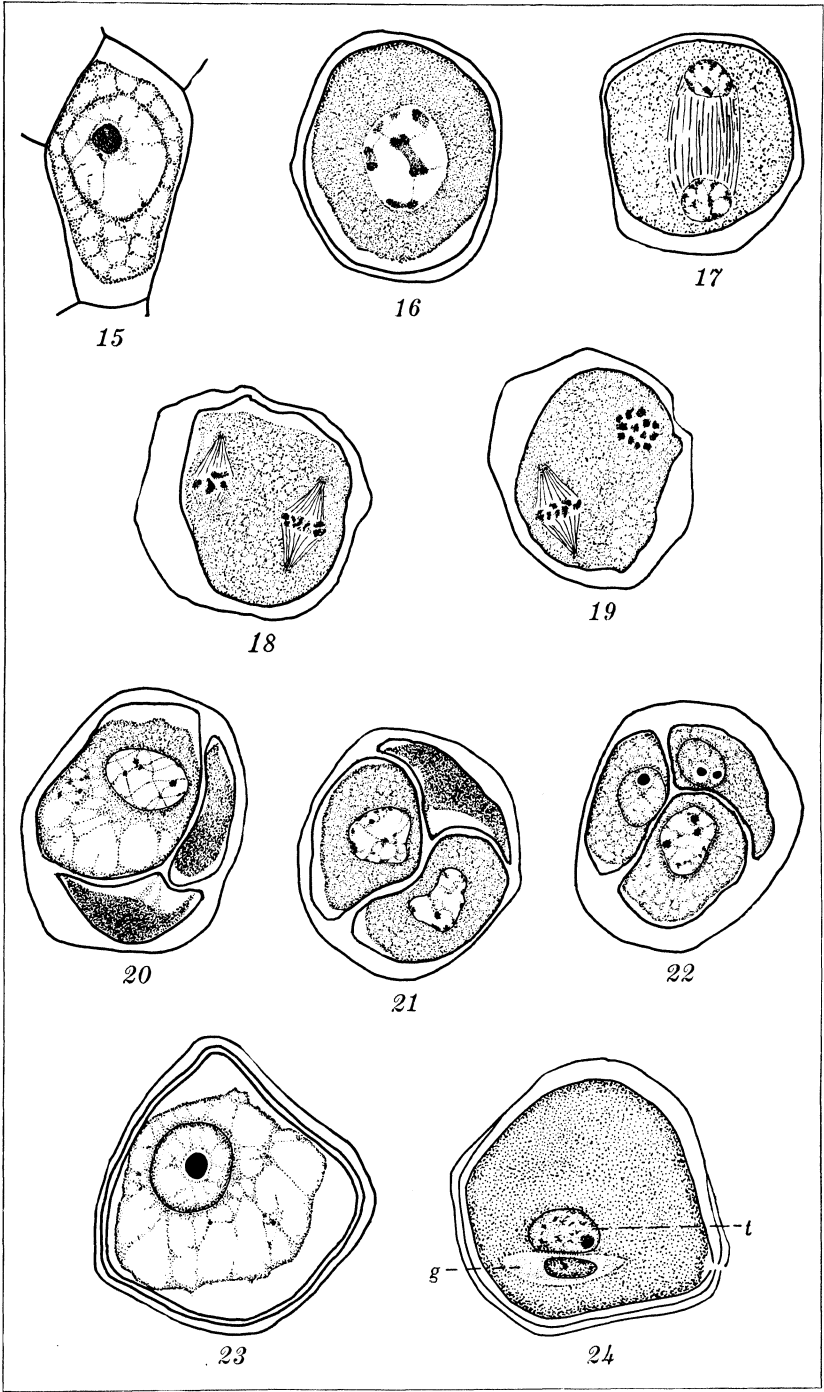


PLATE 3.

LEPROSY IN CEBU, I

By JOSÉ RODRIGUEZ
Of the Philippine Health Service

TWO TEXT FIGURES

GEOGRAPHICAL CONSIDERATIONS AND POPULATION

Cebu is an elongated island barely 36 kilometers at its widest point with a length of 223 kilometers and a total area of 4,836 square kilometers. Its long axis trends north-northeast and south-southwest, and the mainland lies between $123^{\circ} 17' 34''$ and $124^{\circ} 4' 4''$ east longitude and $9^{\circ} 24' 46''$ and $11^{\circ} 17' 11''$ north latitude.

The island is bounded on the north by the Visayas Sea, on the east by the Camotes Sea and Bohol Strait, on the south by the Mindanao Sea, and on the west by the narrow Tañon Strait which separates it from Negros. The province comprises a considerable number of minor islands, of which only fourteen have an area of one square mile or over. The more important of these are Bantayan, Mactan, Poro, Paajan, and Ponson.

Although mountains extend almost throughout the entire length of Cebu, their altitude is not great, compared with the towering ranges in the surrounding islands. In reality, this island is the lowest of the larger Visayan islands. This fact has a decisive influence on the climate of Cebu, which will be discussed later.

The highest peak is Mount Uling, 1,013 meters, found in the central part. From this peak, the land slopes down gradually on all sides to form the central plateau which has one of the most fertile soils in Cebu.

The coastal plains are very narrow, widening out only around the city of Cebu and at the town of Tuburan. There is also a fairly rich plain towards the north, where Bogo is located. These plains form one of the most thickly populated regions in the Philippines.

The soil is porous and so thin that the coral subsoil crops out on the surface even in the most fertile regions. This character of the soil, together with the scanty rainfall, makes Cebu unfavorable for rice growing. Corn, the staple food of the

people of Cebu, grows very well, so that three harvests a year are possible in most parts of the island. Other products are coconuts, sugar cane, peanuts, bananas, pineapples, camotes, maguey, and kapok.

The physiography of the island affords very few rivers, which become veritable torrents washing down the soil of the highlands to the coastal plain below shortly after heavy rains, but dwindle to mere rivulets in the dry part of the year. Wells are deep and difficult to dig, so that in most places water for bathing purposes is difficult to obtain and the populace in the past had to depend on rain for drinking water.

The difficulty of obtaining a water supply does not encourage bathing among the people and the masses are dirty as a rule, and skin diseases of all kinds are very common. This unfortunate condition has been much improved during the last few years through the building of waterworks and the drilling of artesian wells in the more important towns. There are at present 583 artesian wells serving 290,000 people, and 25 water works, serving 400,000 inhabitants. In addition, there are 547 sanitary dug wells, serving 85,000 people, and 510 insanitary dug wells serving another 100,000.

According to the census of 1918, there is a total of 252,316 hectares of agricultural land, of which only 128,819, or 51.1 per cent, was under cultivation in that year. From personal observation, however, it is quite apparent that all the arable and much of the poor land is under cultivation, and even the steep hill-sides are planted to corn and other products.

The island is rich in minerals, the most important being coal and gold. The government cement plant at Naga turns out good cement and the supply of crude material is unlimited.

Good fishing banks are found along the coast. The inhabitants of a few of the municipalities, such as Bantayan and Cordova, depend almost entirely on fishing for their living. Hogs and goats are raised for local consumption. Chickens and eggs are exported to Manila. Tuba, a fermented drink from the coco palm, is consumed in large quantities in many localities.

According to population, Cebu is the most important province in the Philippines. In the last census, that of 1918, the population was placed at 855,065. In the 1903 census, it was 653,727, representing an increase of 30.8 per cent in fifteen years, or 2.1 per cent per year. Thus the increase is considerable, in spite of continuous emigration to neighboring provinces—Leyte, Samar, Occidental Negros, and Oriental Negros—as well as to Min-

doro, Mindanao, and Hawaii. During the nineteenth century, the population of Cebu showed remarkable increases. The following figures were obtained from Buzeta and Bravo; 100,000 inhabitants in 1799; 334,790 in 1846; and 389,073 in 1850.

In 1898, Lebres gave the official population as being around 520,000. The estimated population of the province, according to figures available at the District Health Office, was 994,365 on December 31, 1929.

CLIMATE

There is one first-class meteorological station located at the capital and five rain stations in different parts of the province. The Dalaguete, Cebu, and Bogo stations are located in the southern, middle, and northern portions of the eastern coast, respectively, and are all practically at sea level. The station at Biaong Cui's Farm, within the jurisdiction of the town of Barili, is the most elevated, 60 meters, and is located on a slope of the central ridge. The only station on the western coast of the island is located at Tuburan. A coöperative station was established at Talisay in May, 1928.

The climate of Cebu is determined chiefly by the low altitude of its mountains and its location in the central Visayas region, surrounded by a number of islands covered by high mountain ranges. The mountains of Negros precipitate most of the rain during the southwest monsoon, while the high ranges of Samar and Leyte cut off the moist winds during the northeast monsoon. This makes the rainfall scanty, and the province is one of the driest in the Philippines. However, this rainfall is very evenly distributed, and this makes the climate suitable for corn and other products.

The data used in the following discussion were obtained directly from the Weather Bureau and from the 1918 census.

Temperature.—The various stations in the province show only slight differences in the temperature. For this reason the data for Cebu, the oldest station, will be used as the basis for the discussion on the climate. When there exist notable differences between various stations, these will be mentioned.

Table 1 gives the normal monthly and annual temperatures for all the stations, and Table 2 shows the means of the annual extreme temperatures.

The tables reveal no marked change in the temperature variations in the different stations throughout the year. As is to be expected, there is a higher mean annual range of temperature as well as mean absolute annual range for the Biaong Cui's Farm

TABLE 1.—Showing the normal monthly and annual temperatures and the mean annual ranges in C°.

Station.	Mean annual range.	January.	February.	March.	April.	May.	June.
Dalaguete.....	2.1	26.2	26.5	26.9	28.2	28.3	27.8
Biaong Cui's Farm.....	2.9	24.8	25.1	25.5	27.2	27.7	27.4
Cebu.....	2.1	26.0	26.0	26.8	27.7	28.1	27.8
Tuburan.....	2.9	25.5	25.5	26.1	27.5	28.4	28.0
Bogo.....	2.5	26.7	27.0	27.5	28.9	29.2	28.2

Station.	July.	August.	September.	October.	November.	December.	Average.
Dalaguete.....	27.6	27.8	27.8	27.6	27.2	26.6	27.4
Biaong Cui's Farm.....	26.9	27.4	27.0	26.7	26.1	25.4	26.6
Cebu.....	27.4	27.5	27.3	27.1	26.8	26.5	27.1
Tuburan.....	27.8	27.9	27.4	27.2	27.7	26.0	27.0
Bogo.....	27.8	27.9	27.9	27.7	27.6	26.8	27.7

TABLE 2.—Showing the means of annual extreme temperatures and the mean absolute annual range in C°.

Temperature.	Dalaguete.	Barili.	Cebu.	Tuburan.	Bogo.	Average.
Maximum.....	34.8	35.9	33.8	35.6	35.6	35.1
Minimum.....	20.2	19.6	20.4	18.1	21.3	19.9
Mean absolute range.....	14.6	16.3	13.4	17.5	14.3	15.2

Station, which is located at a higher altitude than the others. The corresponding figures for Tuburan on the western coast are also higher than those for Cebu, Dalaguete, and Bogo on the opposite coast, showing that there is a wider variation of temperature on the western than on the eastern side of the island.

The average means of the upper and lower extremes of temperature for the entire province are 35.1° C. and 19.9° C., respectively, with a mean absolute annual range of 15.2° C. The mean of the maximum annual temperature, although varying with local conditions, is quite in accord with that of the rest of the Visayas, which is generally lower than the corresponding figure for Luzon. On the other hand, the mean of the minimum

annual temperature is higher in the Visayas including Cebu, so that the range of the temperature is lower than in Luzon.

The figures for the daily extremes of temperature are interesting, for although the daily mean maximum temperature for Cebu (30.6° C.) is not very high, compared with Dagupan (30.0° C.), for example, the mean diurnal range is very small, being only 6.6° C. (Dagupan, 10.2° C.) which is the lowest among the ten stations located in the Philippines according to the 1918 census. It is thus demonstrated that although the mean annual temperature for Cebu (27.1° C.) is only slightly higher than the average of 26.9° C. for the entire Philippines, the climate seems warmer than it really is on account of the lack of vegetation, the character of the soil, and the low diurnal range.

The extreme regularity in the sequence of its normal diurnal monthly and annual changes of temperature is remarkable.

Rainfall.—According to the classification of the Weather Bureau, as given in the census of 1918, the monthly distribution of rainfall in the Philippines may be divided into two main types and two other intermediate types, as follows:

First Type: Two pronounced seasons, dry in winter and spring, wet in summer and autumn. Only the cyclonic or summer rainfall prevails, the other being hardly noticeable; hence the dry season of winter lasting from three to six or seven months. This is the type shown by the monthly distribution of rainfall in all the stations on the western part of the islands of Luzon, Mindoro, Negros and Palawan, and the western and southern part of Panay.

Second Type: No dry season; with very pronounced maximum rain period in winter. The regions enjoying this type of climate or of monthly distribution of rainfall are Catanduanes, Sorsogon, the eastern part of Leyte, and a great portion of the eastern part of Mindanao. There is in the regions of this type much cyclonic or summer and autumn rainfall; but the maximum monthly rainfall is generally that of December and January, while the monthly amounts of rain for the summer and autumn months are far from being so great. There is not a single month dry in regions of this type, the minimum monthly rainfall occurring in some places in spring, in other places in summer.

Third or Intermediate A Type: No very pronounced maximum rain period; with a very short dry season, lasting only from one to three months. This type is intermediate between the preceding two, although it approaches more the first type inasmuch as there is a short dry season. Regions with this type of climate are the western part of Cagayan, Isabela and Nueva Vizcaya Provinces, the easternmost part of the Mountain Province. A small portion of southern Tayabas, Masbate, and Romblon, the northeastern part of Panay, the eastern part of Negros, the central and southern part of Cebu, part of Misamis, Agusan and Bukidnon Prov-

inces, the peninsula of Zamboanga, and a good portion of eastern Palawan. The short dry season experienced in regions of this type occurs in some places in winter, in others in spring.

Fourth or Intermediate B Type: No very pronounced maximum rain period and no dry season. This is also an intermediate type between the first and second, but approaching more the second inasmuch as there is no dry season in it. Regions with this type of climate are the Batanes Province, the easternmost part of northern Luzon from Cagayan Province to about one-third of the Tayabas east coast, the western part of Ambos Camarines and Albay Provinces, the Bondoc Peninsula, the eastern part of Mindoro, Marinduque, a small portion of Samar near Calbayog, the western part of Leyte, *the northernmost part of Cebu*, the Islands of Bohol, Jolo, and Basilan, and a great portion of Mindanao, including the Provinces of Lanao, Cotabato, the western part of Davao and Misamis Provinces and the eastern part of Zamboanga Province.

It is thus seen that, according to this classification, the middle and lower thirds of Cebu, including the Dalaguete, Biaong Cui's Farm, and Cebu stations belong to the Third or Intermediate Type A, while the northern third (Tuburan and Bogo stations) falls under the Fourth or Intermediate Type B.

Careful analysis of more recent data obtained from the Weather Bureau appearing in Table 3, which gives the average monthly and annual rainfall of the different stations, raises some doubt as to the accuracy of previous data on which the classification has been based. According to the table, Tuburan situated in the northern third has the lowest annual rainfall, as well as the lowest in any month, there being an average of only 9.9 millimeters for April. During March also it shows a rainfall of less than 50 millimeters (40.9 millimeters). On the other hand, Dalaguete on the southern end of the island has only one month (April) below 50 millimeters (48.0 millimeters). Therefore, there is more of a dry season in Tuburan (northern part) than in Dalaguete (southern part), which is against the classification given above.

Commenting on this, the Director of the Weather Bureau says, in a communication dated November 17, 1928:

According to recent data, it would seem probable that the northern part of Cebu Island will have to be considered as of the Third or Intermediate A Type with no very pronounced maximum rain period and with a short dry season of from one to three months, as those of the central and southern part. Yet we have to wait for more years of observation until this can be definitely decided.

The rainfall is naturally heavier in Biaong Cui's Farm which is on a higher elevation than the other stations. The annual

TABLE 3.—*Showing the average monthly and annual rainfall for the various stations in Cebu.*

Station.	January.	February.	March.	April.	May.	June.	July.
Dalaguete.....	134.3	81.4	87.8	48.0	115.8	135.6	141.5
Biaong Cui's Farm.....	157.6	104.1	74.0	50.0	121.7	148.5	127.1
Cebu.....	95.0	73.5	48.6	38.6	95.0	180.6	157.1
Tuburan.....	112.3	67.5	40.9	9.9	59.9	130.7	148.5
Bogo.....	133.8	74.6	79.5	36.1	121.3	168.8	204.2

Station.	August.	September.	October.	November.	December.	Annual.
Dalaguete.....	104.4	149.2	158.8	182.5	164.6	1,503.8
Biaong Cui's Farm.....	96.4	149.6	222.8	218.0	194.5	1,659.5
Cebu.....	142.5	189.8	224.9	188.2	146.0	1,529.8
Tuburan.....	99.6	178.1	170.0	153.0	114.5	1,284.9
Bogo.....	136.4	180.5	192.6	282.1	181.1	1,492.1

rainfall for Tuburan is considerably lower than for the three stations on the other side of the island.

In order to show the differences in the distribution of rainfall in Cebu in different seasons of the year, I have added the average rainfall for each station during the four months in which the summer or cyclonic rains are more abundant—namely, June, July, August and September—and compared the total with that for the four other months in which the northeast monsoon (winter) rains occur—namely, November, December, January and February. The result is shown in Table 4.

TABLE 4.—*Seasonal average rainfall for all stations in Cebu Island.*

Station.	June to September (southwest monsoon).	November to February (northeast monsoon.)
Dalaguete.....	534.7	562.8
Biaong Cui's Farm.....	531.6	669.2
Cebu.....	670.0	452.7
Tuburan.....	556.9	447.3
Bogo.....	689.9	611.6
Average.....	598.6	548.7

The table proves that there is no very pronounced rain period throughout the province. The rainfall is slightly more marked during the northeast monsoon months in Dalaguete and Biaong Cui's Farm, or the southern part of the island. On the other hand, there are more rains during the southwest monsoon period in the northern part. Aside from this, there seems to be no demonstrable difference in the rainfall characteristics of the different parts of the island.

The average annual rainfall throughout the island is low, being only 1,494.0 millimeters, compared with the average of 2,366.1 millimeters for the rest of the Archipelago. This province is one of the driest in the Philippines, and is surpassed in this respect only by Nueva Vizcaya, Misamis, Oriental Negros, and Bohol.

Humidity and cloudiness.—Data for humidity and cloudiness are available only for the capital. Cebu shows the lowest annual mean humidity of all the stations in the Philippines. The mean annual range of oscillation is also very small, so that the atmosphere is comparatively dry in spite of the relatively small size of the island and the large bodies of water around it. This may be attributed chiefly to the low rainfall and scanty vegetation. April is the least humid month, and December is the most humid.

A graphic representation of the monthly and annual mean relative humidity of the city of Cebu, compared with Manila, is given in fig. 1.

The Cebu skies are clear compared with other stations; the mean annual cloudiness is only 5.5 per cent, the lowest among all stations in the Islands except Legaspi.

Summarizing the climatological characteristics of Cebu Island, it may be said that the mean annual temperature is only slightly higher than the average for the Philippines, but due to the low range of the daily, monthly, and annual temperature variations, the climate seems warmer than that of many other provinces in the Philippines. This peculiarity of the Cebu climate has been well known since the Spanish time. The rainfall is scanty and is fairly well distributed throughout the year. The humidity is low with very little seasonal variation. In short, the chief characteristic of the Cebu climate is the little variation in the temperature, rainfall, and humidity from month to month and from year to year.

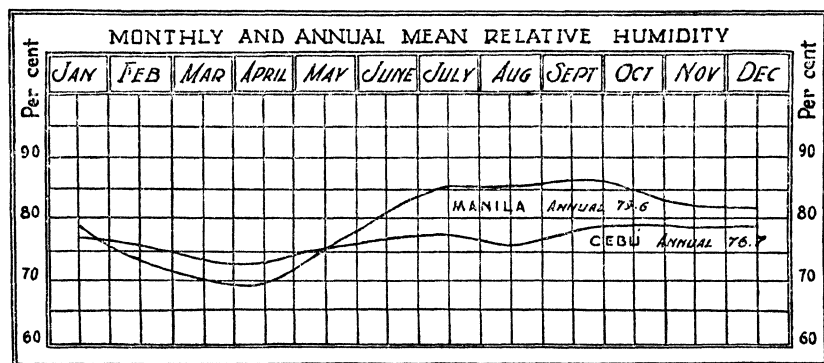


FIG. 1. Monthly and annual mean relative humidity of Manila and Cebu, Philippine Islands.

HISTORICAL SKETCH

The manner in which leprosy was introduced in Cebu and the rest of the Archipelago remains to be fully established. It is now practically certain that those who ascribe the introduction of leprosy to the bringing of 130 Japanese lepers to Manila in 1630 are in error and that leprosy was already prevalent in certain regions before that year. Barely seven years after the occupation of Manila by Legaspi in 1570, Father Juan Clemente, a Franciscan lay brother, was kept busy at the door of the newly established Franciscan church ministering to the needs of numerous patients among whom were many lepers. Lepers were also so numerous in the Bicol provinces of Albay and Sorsogon that a hospital for lepers was established at Nueva Caceres, then the capital of the Bicol region, barely thirteen years after Salcedo explored that region.

The possibility that the disease may have been introduced from the continent by Siamese, Chinese, and Japanese traders has to be kept in mind. Guerrero is inclined to believe that the disease was introduced here by Malay settlers from the Malay Archipelago who in turn got it from their ancient Hindu colonizers.

The disease was also encountered in less-populated provinces; by Comin in Leyte, and by Fray Juan in La Union.

The disease, however, did not gain much headway until quite recently when, with the introduction of better transportation and communication facilities, it spread with alarming rapidity.

The spread of leprosy in Cebu at the beginning of the nineteenth century must have been very rapid. No reference to the disease can be gleaned from official and ecclesiastical reports prior to this time. This was partly due to the fact that the disease was then probably not so prevalent, and partly because the officials were indifferent to such unproductive matters as leprosy. It is certainly to be regretted that the Franciscan Order did not settle in Cebu, as the monks of this order established the first hospitals in the Philippines and for a time were the only ones concerned with the health of the natives. Their chronicles are the only available sources of information regarding leprosy in the early days of Spanish domination.

But by 1817, the lepers had become so numerous that Hospital de San Lazaro had to be built for them by the Bishop Joaquin de Sopetran out of his own funds aided by some donations. By Real Cedula in 1819, it was placed under the patronage of King Ferdinand VII. In spite of royal favor, however, the hospital from the start passed through many vicissitudes and a few years later, partly due to the poor material used in its construction and partly due to the failure of the business where the trust fund had been invested, the building fell in ruins and the patients were thrown out upon the streets.

It was through the efforts of one of the most active bishops that Cebu has ever known, Bishop Romualdo Gimeno, that the building which was in use until as late as 1921 was built. It was inaugurated on April 1, 1854, after five years of construction, a period beset with many difficulties. The funds were derived from the private coffers of the bishop and from donations from the clergy and the faithful, as well as from liberal subsidies from the insular and provincial governments.

The building was of stone and first-class wood, and could accommodate about one hundred lepers.

Segregation of the sexes was effected by a central partition dividing the hospital into two parts. The personnel lived in a separate building which was, however, built so close to the hospital proper as to form almost a single structure with it. To prevent the possibility of contagion through the pestiferous emanations from the patients, a possibility much thought of in those days, the chapel was shut off from the congregation by glass doors.

The purpose of the hospital was to offer a place of refuge for indigent lepers. However, the inmates were free to come and

go, so that there was no segregation in the real sense of the word.

The hospital was maintained as follows: 1,842 dollars (Mexican currency) were obtained from provincial funds, 200 from a savings bank account maintained by friars of the Recollect Order in Manila, 100 from a similar account maintained by the Archbishop of Manila, and from minor donations which amounted to another 100 dollars. The hospital was operated at a considerable deficit, which was covered from the bishop's own funds.

Due to the stability of the above funds and the interest of succeeding bishops, the hospital continued to be the refuge of indigent lepers for over half a century.

In 1886, the Spanish authorities set aside the small island of Paniltugan, one of the lesser islands of the Bantayan group off the northwest coast of Cebu, as a reservation for lepers from the nearby municipalities. Lepers from the municipalities of Medellin, Daanbantayan, Bantayan, and even from San Carlos on the mainland of Negros, were apprehended by local police and brought to the island. Here, they were left to their own devices. Fortunately, the island is fertile and fish are abundant along the shores. On Sundays, the lepers were allowed to beg in the streets of the town of Bantayan which they reached by means of bancas.

It is interesting to record that a number of non-lepers are said to have gone to the island to live with the lepers. Most of them were members of the families of the lepers, although a few voluntarily exiled themselves there to escape the taxes. It is said that five families hid on the island and thus escaped the collections. When a census of the inhabitants of the island was taken in 1907 previous to sending the lepers to Culion, it was discovered that there were 70 persons, of whom only about two-thirds were lepers. None of the rest was known to have developed leprosy subsequently.

In spite of the above measures, the disease increased by leaps and bounds and toward the close of the last century conditions, particularly in the city itself, became alarming. At the instance of the Governor, Inocencio Junquera, Dr. Manuel Rogel Lebres, "medico titular" of the province, made a survey of the lepers begging in the streets of Cebu. Within a few days, he had examined 426. This did not include lepers among the rich nor young children. Furthermore, Lebres averred that as soon as the lepers became aware of this survey, many hid themselves

or left the city and, therefore, were not included in his list. He estimated that there must have been more than 2,000 lepers in the province at the time the survey was made.

For a time the local government considered ways and means to counteract the advance of the disease, but before anything could be done, a prolonged debate was started in local papers, and soon after the Manila periodicals took up the subject.

Rogel Lebres courageously and ably defended his contagionist views and advocated the segregation of the lepers in some of the smaller islets near the coast of the larger islands, but his efforts proved of no avail against the attacks of certain fashionable physicians in Manila who had found it convenient to hold the opposite view. The result was that Lebres was transferred to another district in Bohol Island. Thus was the debate terminated, and the lepers once more were left begging in the streets of Cebu unmolested.

At this juncture, a slight digression may be permitted to describe a book on leprosy written by Rogel Lebres, entitled, *Leprosy in Bisaya*, published in 1897, and considered the best work on the disease published during the Spanish régime. How the author came to write the book is described in the foreword. After his transfer from Cebu to Bohol Province, he was alarmed at the number of lepers he found there. Wishing to know more of the disease, he ordered from Paris as many books on leprosy as could be purchased with a certain sum in pesetas. Due to an error of his intermediary, however, the order was placed in pesos instead of pesetas so that three months later, to his "no little disgust" he received twelve certified packages containing books on leprosy, forming a bulk "which two men could hardly carry." But came the day when with nothing else to read and surrounded by these books, almost by necessity he eventually read through them all and afterwards decided to set down his own ideas in book-form.

His book contains a good presentation of the views on leprosy current at the close of the nineteenth century. His data on the disease as encountered in Cebu and Bohol were first hand and are the only available ones describing conditions in these provinces over thirty years ago. His data on the other provinces were not as complete.

He proposed the complete segregation of all lepers in small islets near the main ones, to be placed in charge of friars, as the only means to stamp out the disease. Needless to say, the idea was not even tried.

The Americans found the streets of the city itself thoroughly infested with leprous beggars, and as early as 1902 efforts were made to round them up and segregate them in the old hospital building and its environs.

In 1907, the lepers collected in the city of Cebu, together with about 300 from other municipalities, were shipped to Culion on two coast-guard steamers, these forming the first group of lepers to be admitted to that colony. Since that first shipment, two collections have been made every year for Culion, the number depending on the number apprehended during the intervals. After the establishment of the Culion Leper Colony, the old leper hospital in Cebu was used as detention camp where the lepers awaiting shipment to Culion were kept.

In 1921, the old building, being in a dilapidated condition, was vacated and the lepers were housed in temporary bamboo shacks built on the grounds of the old building.

A modern up-to-date hospital recently has been constructed at Jagubiao, between Mandawe and Consolacion, 11 kilometers from the city. The hospital occupied on May 26, 1930, was built from funds donated by Mr. Eversley Childs, of New York. The site, consisting of about 27 hectares of high ground and 26 hectares of swamp is a gift of Cebu Province. This leprosarium is officially designated the Eversley Childs Treatment Station. The new hospital is a very attractive place and will doubtless play an important rôle in the final eradication of the disease in Cebu by attracting those who previously would have hidden out.

INCIDENCE OF LEPROSY IN CEBU

Official statistics support the prevailing belief that Cebu is the most heavily infected province in the Philippines. According to the records of the Culion Leper Colony, 4,844 out of 19,100 admissions to the colony from 1906 to 1929, inclusive, were from this province. Records available at Cebu show that 5,290 lepers have been segregated from the province from 1902 to 1929, inclusive. It will be noticed that this total is larger than the Culion figure for the simple reason that it is based on the number segregated for a period of twenty-eight years, instead of only twenty-four years for Culion. In other words, for four years before the establishment of Culion, lepers were already being segregated in Cebu. Four hundred forty-six of them never reached Culion; this figure probably represents

deaths and escapes combined. Of the total number, 1,393, or almost one-fourth, came from the City of Cebu itself.

Table 5 gives the incidence based on the number of lepers collected from each of the fifty-two municipalities of the province during the period stated above, and on the estimated population of each as of December 31, 1929.

TABLE 5.—*Showing the relative incidence of leprosy based on number of lepers collected in twenty-eight years (1902–1929) per 1,000 inhabitants.*

Municipality.	Estimated population as of December 31, 1929.	Total number collected, 1902–1929.	Relative incidence per 1,000 inhabitants.
Alcantara.....	8,827	3	0.4
Alcoy.....	6,649	8	1.2
Alegria.....	14,332	26	1.8
Aloguinsan.....	14,023	68	4.9
Argao.....	41,081	102	2.5
Asturias.....	17,163	60	3.5
Badian.....	20,650	70	3.4
Balamban.....	23,428	41	1.7
Bantayan.....	15,974	84	4.7
Barili.....	34,677	139	4.0
Bogo.....	20,017	69	2.4
Boljoon.....	10,156	58	5.8
Borbon.....	12,188	23	1.9
Carcar.....	40,527	350	8.7
Carmen.....	11,166	24	2.2
Catmon.....	23,258	22	0.9
Cebu.....	78,131	1,393	17.7
Compostela.....	7,668	16	2.1
Consolacion.....	7,866	58	7.3
Cordova.....	6,110	127	20.0
Daanbantayan.....	24,819	72	2.9
Dalaguete.....	30,376	130	4.3
Danao.....	25,995	73	3.1
Dumanjug.....	24,571	45	1.8
Ginatilan.....	12,718	32	2.5
Liloan.....	13,792	65	4.4
Madridejos.....	3,877	9	2.3
Malabuyoc.....	16,723	14	0.84
Mandawe.....	24,998	205	8.25
Medellin.....	17,795	30	1.7
Minglanilla.....	16,886	94	5.6
Moalboal.....	16,593	40	2.4
Naga.....	23,613	201	8.5
Opon.....	25,221	402	16.0
Oslob.....	13,698	39	2.9
Pilar.....	5,653	2	0.4
Pinamungajan.....	20,682	49	2.3
Poroc.....	7,690	3	0.4

TABLE 5.—*Showing the relative incidence of leprosy based on number of lepers collected in twenty-eight years (1902-1929) per 1,000 inhabitants—Continued.*

Municipality.	Estimated population as of December 31, 1929.	Total number collected, 1902-1929.	Relative incidence per 1,000 inhabitants.
Ronda.....	12,134	22	1.8
Samboan.....	13,927	12	0.9
San Fernando.....	22,819	112	4.9
San Francisco.....	12,375	30	2.4
San Remigio.....	21,091	18	0.8
Santa Fe.....	6,679	20	3.0
Santander.....	8,323	4	0.5
Sibonga.....	27,920	146	5.2
Sogod.....	9,884	15	1.5
Tabogon.....	22,272	45	2.0
Talisay.....	16,313	427	26.4
Toledo.....	31,862	111	3.4
Tuburan.....	36,721	75	2.0
Tudela.....	6,156	7	1.1
Total.....	994,365	5,290	-----

Analysis of Table 5 shows that the incidence ranges from 0.4 to 26.4 per thousand. It must be emphasized that these figures are based on total collections during a period of twenty-eight years and give only the relative incidence of the disease in the different municipalities.

A map of the province (fig. 2) indicates graphically the relative frequency of leprosy in its fifty-two municipalities. The blank spaces indicate municipalities from which an average of less than one leper was collected annually during the last twenty-eight years per 1,000 inhabitants living therein by the end of 1929; the shaded ones indicate an incidence of from 1 to 4 per 1,000; the crosshatched from 5 to 10 per 1,000; and the solid areas over 10 per 1,000. Thus, there are municipalities where the disease may be said to be nonexistent; the few cases reported from them probably came originally from the more heavily infected towns. On the other hand, there are other municipalities that have been heavily and almost alarmingly infected. Yet, all of these towns are located on a small island, apparently differing very slightly from neighboring islands in climatological characteristics, habits of the inhabitants, physiography, etc. Then again when a more minute survey of the incidence is made locally in a heavily infected municipality, this unequal distribution is again encountered, for here once more the disease is not evenly distributed throughout the population.

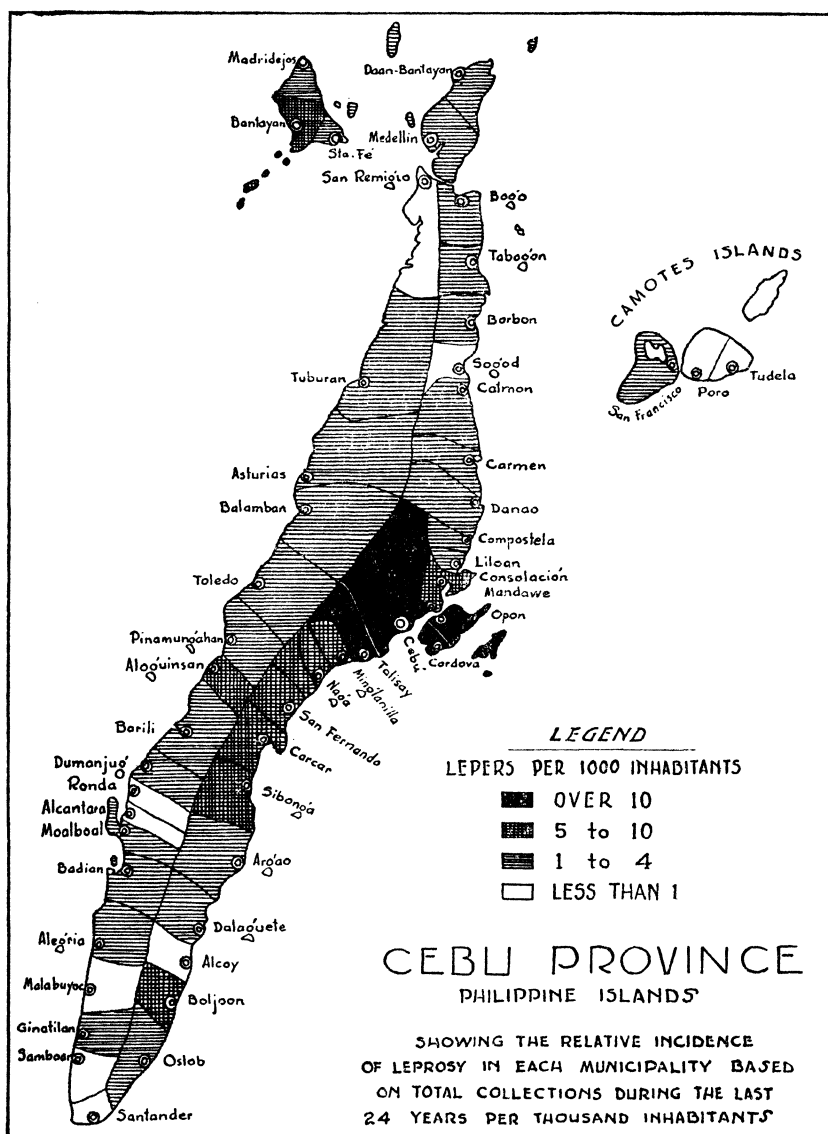


FIG. 2. Cebu Province, Philippine Islands, showing the relative incidence of leprosy in each municipality.

The lepers who have been segregated will be found to have lived almost exclusively in certain barrios or districts which are well known to the townspeople, while the rest of the municipality will be found to be practically free.

The map indicates that the principal focus of leprosy has for its center the capital itself and includes, in addition, the town of

Talisay to the south and the municipalities of Opon and Cordova, both located on Mactan Island, towards the north. The data in Table 5 tend to show that Talisay is the most heavily infected municipality, followed by Cordova, Cebu, and Opon, in the order named. The primary focus can be inclosed within a circular area with a radius of about 20 kilometers having the heart of the capital as its center. This area, with its population of 125,000 by the end of 1929, which is only about one-eighth of that of the province and about one one-hundredth of that of the Philippines, has yielded 2,349 lepers since the beginning of the segregation system in 1902, or more than two-fifths of the total collected from the province and one-eighth of all the admissions to Culion. It is probably the most important focus of leprosy in the Philippines.

From this main endemic area, the disease seems to have spread northward and southward along the narrow costal plain although it disseminated farther south than north. Northward the incidence drops off rather suddenly beyond Consolacion (12 kilometers from Cebu), while towards the south, the crosshatched area reaches as far as Carcar (40 kilometers from the capital). There appear to be isolated secondary foci at Boljoon in the south, at Alonguinsan across the island from the capital, and on Bantayan Island to the north.

It would be interesting to investigate the reasons for this striking distribution of the disease in Cebu Province. The variations in the incidence should be explained on historical grounds as well as on variations, if any, of such factors as density of population, economic condition as well as the main occupation and habits of the inhabitants, climatological differences, kind of soil, source of food, water supply, flora and fauna, etc., as found in the heavily infected areas compared with the same factors prevailing in those relatively free of the disease. However, such work, to be of any practical value, needs years of patient effort, and the results will have to be carefully sifted.

We will take up in this paper the possible influence of density of population and the climate, leaving the discussion of the other subjects to subsequent papers. It has already been stated that on historical grounds no interesting leads have been discovered so far, principally due to the absence of written records.

INFLUENCE OF DENSITY OF POPULATION ON INCIDENCE OF LEPROSY

Table 6 is shown for the purpose of indicating the possible influence of the density of population on the incidence of lep-

rosy. The figures for the incidence were obtained from Table 5, while the density was based on the population as of 1929, per hectare of cultivated territory as given in the 1918 census. It is to be regretted that it is not possible to make the latter figure up to date, but all authorities agree that there has been very little change in the area of cultivated agricultural land in Cebu since 1918.

TABLE 6.—*The relative incidence of leprosy and the density of population per hectare of cultivated territory in each municipality.**

Municipality. ^b	Incidence per 1,000 inhabitants.	Density of population per hectare. ^a
Alcantara.....	0.4	5.8
Alcoy.....	1.2	5.5
Alegria.....	1.8	8.9
Aloguinsan.....	4.9	4.09
Argao.....	2.5	8.9
Asturias.....	3.5	9.99
Badian.....	3.4	7.99
Balamban.....	1.7	10.8
Bantayan.....	4.7	8.4
Barili.....	4.0	11.06
Bogo.....	2.4	4.9
Boljoon.....	5.8	5.5
Borbon.....	1.9	5.6
Carcar.....	8.7	5.8
Carmen.....	2.2	4.7
Catmon.....	0.9	4.9
Cebu.....	17.7	18.7
Compostela.....	2.1	-----
Consolacion.....	7.3	-----
Cordova.....	20.0	7.3
Daanbantayan.....	2.9	6.7
Dalaguete.....	4.3	9.1
Danao.....	3.1	6.3
Dumanjug.....	1.8	6.3
Ginatilan.....	2.5	9.1
Liloan.....	4.4	2.8
Madridejos.....	2.3	8.7
Malabuyoc.....	0.84	6.9
Mandawe.....	8.25	7.3
Medellin.....	1.7	5.3
Minglanilla.....	5.6	8.9
Moalbual.....	2.4	6.8
Naga.....	8.5	6.7
Opon.....	16.0	6.1
Oslob.....	2.9	10.5

* Population as of December 31, 1929, and area of cultivated territory as per census of 1918.

^b The municipalities of Compostela and Consolacion are not included because no data as to the area of their respective cultivated lands could be obtained.

TABLE 6.—*The relative incidence of leprosy and the density of population per hectare of cultivated territory in each municipality*^a—Ctd.

Municipality. ^b	Incidence per 1,000 inhabitants.	Density of population per hectare. ^a
Pilar.....	0.4	4.4
Pinamungajan.....	2.8	7.9
Poro.....	0.4	3.4
Ronda.....	1.8	14.1
Samboan.....	0.9	9.5
San Fernando.....	4.9	8.1
San Francisco.....	2.4	3.1
San Remigio.....	0.8	9.9
Santa Fe.....	3.0	7.1
Santander.....	0.5	10.0
Sibonga.....	5.2	9.3
Sogod.....	1.5	1.1
Tabogon.....	2.0	5.1
Talisay.....	26.4	11.1
Toledo.....	3.4	11.1
Tuburan.....	2.0	8.35
Tudela.....	1.1	4.84

^a Population as of December 31, 1929, and area of cultivated territory as per census of 1918.

^b The municipalities of Compostela and Consolación are not included because no data as to the area of their respective cultivated lands could be obtained.

By simple inspection of the table, the relation of the density of the population to the incidence is not quite apparent, but when the data are treated biometrically to determine the degree of correlation, the result becomes clear. The calculations were made by Prof. Sofronio Balce, of the Junior College of Cebu, and confirmed by Dr. Francisco Perez, of the Department of Mathematics, College of Liberal Arts, University of the Philippines, to both of whom the writer is deeply indebted. They found the correlation coefficient to be 0.3335 ± 0.08477 , indicating a high degree of correlation.

This result corroborates the findings of Guerrero¹ who used data covering the whole Philippines by provinces. He determined the incidence by securing the number of admissions to the Culion Leper Colony from each province. Thus, the result is the same whether the calculations are based on data by provinces or narrowed down to a single province by municipalities.

Just how overcrowding favors the spread of the disease is, of course, another question. It is easy to understand that the greater the number of inhabitants in a given place, the greater

¹ Journ. Philip. Is. Med. Assoc. 7: 69.

the opportunities of spreading an infection like leprosy by contact. But when the most heavily infected sitios, barrios, or districts are surveyed, it becomes quite plain that close personal contact is not a decisive factor. This is the impression obtained when one visits the heavily infected barrios on Mactan Island where the population is dense, but the individual houses are rather evenly scattered over the territory and not closely grouped.

It may be argued that the important factor brought about by density of population is economic pressure rather than mere physical overcrowding. For this reason, the economic condition of each municipality based on yearly tax collections was correlated with the prevalence of leprosy, but no such close relation was found to exist.

INFLUENCE OF CLIMATE ON INCIDENCE OF LEPROSY

Guerrero has already called attention to the fact that the theory expressed by Rogers and Muir² that there is a close relation between heavy rainfall and high leprosy incidence, is disproved by the distribution of the disease in the Philippines. Cebu Province, the principal focus, has one of the driest climates in the Philippines. As has already been stated in the early part of this paper, the chief characteristic of the Cebu climate is the lack of variation in the temperature, rainfall, and humidity, from day to day, from month to month, and from year to year. This is also true, although to a lesser extent, with Albay and Iloilo, which also are foci of leprosy in the Philippines.

With regard to Cebu Island itself, the differences in climatic conditions between towns with marked variations in the incidence of leprosy is so slight that the climatic factor may practically be discarded as an important etiological factor. The only differences worth noting are that there is a lesser rainfall and a higher mean absolute annual range of temperature registered at Tuburan, a slightly infected town, than at the capital, which is in the center of the main focus. This shows that there is a wider variation of the yearly temperature at Tuburan, thereby again suggesting a relation between prevalence and marked regularity of the temperature.

SUMMARY

Cebu Island, located in the center of the Visayas region, constitutes the principal focus of leprosy in the Philippines and

² Leprosy. John Wright & Sons, London (1925).

is a favorable area for a thorough epidemiological study of this disease. Just how the disease was introduced into the island cannot be determined, but it is known to have spread alarmingly during the early part of the nineteenth century.

The incidence of leprosy in the fifty-two municipalities in the province varies to a remarkable degree; it ranges from an average annual collection during the last twenty-eight years of less than 1 to 26 per thousand. An effort to explain these marked differences between towns separated by only a few kilometers from one another will be the object of further studies locally.

The theory of Rogers to the effect that there is close relationship between the prevalence of leprosy and heavy rainfall is disproved in the Philippines, Cebu being one of the driest islands in the group. On the other hand, the chief characteristic of the Cebu climate is its extreme regularity throughout the year. Within Cebu Province itself, the very slight differences in temperature, rainfall, and humidity between the different municipalities, if at all significant, must play a very minor rôle in explaining the focal character of the distribution.

There is found to exist a certain correlation between density of population and prevalence of leprosy, but the nature of this relation cannot be defined at the present time.

ILLUSTRATIONS

TEXT FIGURES

- FIG. 1.** Chart showing the monthly and the annual mean relative humidity of Manila and of Cebu, Philippine Islands.
- 2.** Map of Cebu Province, Philippine Islands, showing the relative incidence of leprosy in each municipality based on total collections during the last twenty-four years per thousand inhabitants.

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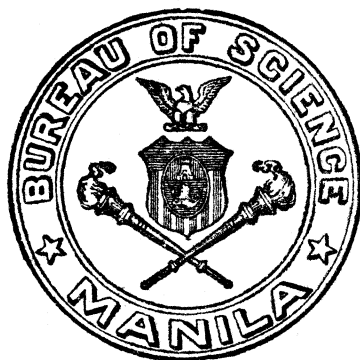
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A PARTIAL REVISION OF THE GANODERMA APPLANATUM GROUP, WITH PARTICULAR REFERENCE TO ITS ORIENTAL VARIANTS

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and

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THIRTY-SIX PLATES AND ONE TEXT FIGURE

INTRODUCTION

Of the wood-destroying fungi none are more common or more cosmopolitan than members of the *Ganoderma applanatum* group, and none show a greater degree of variation from country to country, or even within the limits of a prescribed country. Many specific names have been applied to variants within the group but the characters have often not been sufficiently marked and constant to permit the student of taxonomy to apply them

* The manuscript was entirely prepared by the senior author, who accepts full responsibility for the ideas presented and the data reported. The junior author gave invaluable assistance, however, in working out and recording the microscopic details that are so essential to the interpretation of relationships. She also aided in the tabulation of data, took practically all the photomicrographs of spores, and prepared and supervised the photomicrographing of the free-hand sections showing structure.

To the personnel of the photographic division we are much indebted for patient and courteous service in the preparation of the large number of illustrations, and we are also indebted to the artist, Mr. Macario Ligaya, and his assistants for the tedious task of mounting the thirty-six plates.

with any consistency when large representative collections are brought together from various parts of the world.

Only a cursory examination is necessary for the recognition of the group, since the members have many points in common. The principal distinguishing characters heretofore used in their segregation have largely been such superficial differences as color of the upper surface, form, and thickness of the context, and these are undoubtedly considerably influenced by habitat, climate, and available food supplies. This is likewise true of other wood-destroying groups of world-wide distribution. The genus *Ganoderma* is particularly plastic, however, and this has led to the creation of species where only well-marked varieties or forms are indicated.

Since the group is cosmopolitan it must be studied from the standpoint of its world distribution, as well as its regional. Until one reaches the Tropics few difficulties of interpretation are encountered. In the temperate regions the variations are comparatively minor but the great range of climatic conditions in the Tropics produces a multitude of forms grading one into the other to present a continuous series, the extreme forms of which are readily separable, the intermediates being subject to purely individual interpretation without distinct and consistent features by which to segregate them as species.

While the species-concept in mycology is, admittedly, to a certain extent a matter of individual interpretation, in general, the more material one studies from different parts of the world the broader those concepts become. Variation is but one of the steps in evolution and is normal to all plant life. Progressive variations when they become sufficiently distinct from the recognized type become at best varieties. The principal aim of mycology is to show relationships and, in the opinion of the writer, this can best be accomplished by linking the variations to the base species. The lesser variations (forms) are hardly worth considering from the standpoint of nomenclature, since to be consistent in this respect in a highly plastic group one would need to establish so many forms they would become burdensome and accomplish no useful purpose. From the angle of herbarium practice, where species within the genus are usually arranged alphabetically, the recognition of certain specimens as varieties would automatically place them in their proper position of relationship.

The present investigation was undertaken with the object of determining the range of structural differentiation in the variants already set up as species, in the hope that the microscope would bring to light sufficient fixed characters to allow of a rational segregation. The results obtained are not favorable to close segregation within the group. Appearances, and not definite relationships, have played too great a part, and even these have failed to establish anything sufficiently consistent to be applied by the working mycologist.

The treatment followed in the present paper will, therefore, deviate from past usage principally in reducing several so-called species to varieties or their regrouping under an even broader varietal concept than that originally set up for the species. Such varieties are based in part on spore differentiation and in part on general characters.

HISTORICAL

The genus *Ganoderma* was established by Karsten in 1881¹ for stipitate polypores with a laccate pileus and stipe, *Ganoderma lucidum* (Leys.) being cited as the only member of the new genus; leaving *Ganoderma applanatum* in *Fomes*.

In 1889 he² gave the following generic diagnosis: "Basidia 4-spored, subglobose. Cystidia inconspicuous. Spores ovate or elliptical, verrucose, yellowish-brown" (Translation by M. C. Jensen).

In this same paper (p. 333) Karsten erected the genus *Elfvingia*, citing only *Fomes applanatus* (Pers.) Karst. His characterization of this genus is translated as follows:

"Pileus covered with a brittle crust-like membrane, smooth. Cystidia inconspicuous. Basidia subglobose, 4-spored. Spores ovate, warty, yellowish-brown."

Murrill³ accepted this latter genus but placed with the four brown-spored species, now put in *Ganoderma*, two *Fomes* species with white, smooth spores; namely, *Fomes fomentarius* (L.) and *Fomes fasciatus* (Sw.) (*marmoratus* Berk.).

¹ Enumeratio Boletinearum et Polyporearum Fennicarum in Rev. Mycol. 3 (1881) 17.

² Krit. Öfvers. af Finlands Basidsvampar 327.

³ The Polyporaceae of North America—IV. The genus *Elfvingia*, in Bull. Torr. Bot. Club 30 (1903) 296.

Patouillard ⁴ in 1889 presented a partial outline monograph of the then known representatives of *Ganoderma* in which were included the members of the *applanatum* group. This classification has been followed by the principal European mycologists and also by many of the American. Lloyd ⁵ recognized the genus as section *Ganodermus* of *Polyporus*.

The distinguishing characters of the genus are the obovate, usually apically truncate, yellowish-brown to brown spores, with darker radial striæ in the walls, and the presence of a crust of varying degrees of hardness, this being laccate in most of the softer species. The *applanatum* group, however, rarely shows a specimen with the upper surface varnished even to the slightest degree. The laccate crust, therefore, cannot be considered an essential character and this leaves as the real diagnostic features the peculiar spores.

The members of the *applanatum* group have often been, and still are, placed by some in the genus *Fomes*, which they resemble in their firm to woody consistency and their frequently perennial habit of growth. The characters above outlined, however, are sufficient to make them congeneric with *Ganoderma*, although it would probably be advisable to place them in a separate section from the typical laccate species.

White ⁶ states that spore fall in *Fomes applanatus* under the climatic conditions of Ontario, Canada, begins early in May, when the tubes are about $\frac{1}{16}$ inch in length, and continues quite uniformly until the first heavy frost in late October or early November. While no observations have been made on these points in the Tropics, it has been noted during the course of the present investigation that certain specimens, particularly of variety *philippinense*, are quite devoid of spores, or possess them only sparingly, when the pores are even 1 centimeter long. Fritz ⁷ describes and illustrates cultures of the fungus on different media and reports clamp connections, which are more numerous and conspicuous on Czapek's synthetic medium.

⁴ Le genre *Ganoderma*, in *Bull. Soc. Myc. Fr.* 5 (1889) 64.

⁵ Synopsis of the stipitate polyporoids (1912) 102.

⁶ On the biology of *Fomes applanatus*, in *Trans. Roy. Canad. Inst.* (1919) 139-140.

⁷ Cultural criteria for the distinction of wood-destroying fungi, in *Proc. and Trans. Roy. Soc. Canada III* 17 Sect. 5 (1923) 210-213, pl. 1, figs. 1, 6 (colored), pl. 8, figs. 55-58.

The spores of *Ganoderma* have a dark spiny endospore and a colorless episporium. Coleman⁸ has carefully studied the development of the spore wall and states that after the spore takes on its definitive shape a line of rather coarse granules forms just inside the spore surface. Later these granules fuse into a continuous membrane, from which short projections grow out toward the episporium surface, ultimately reaching almost or quite to the surface of the spore.

In our studies, as will be seen from the numerous photomicrographs presented, we have noted that the usual condition is for the spines to reach entirely to the outside wall of the episporium. Also, the spines are just as commonly parallel sided as tapering. We, therefore, prefer to call them striæ rather than spines, as this is the general effect they produce when examined with an oil-immersion lens.

HOSTS OF *GANODERMA APPLANATUM* AND ITS VARIETIES

As would be assumed from its wide distribution, members of the group have been reported on many hosts in practically all parts of the world. They are common saprophytes on dead trees, logs and stumps, becoming wound parasites of living trees in some instances, in which case they attack the roots or the lower part of the trunk. In the United States Hedgcock⁹ reports *F. applanatus* on thirty-four species of broadleaf trees in sixteen genera: *Acer* (4 species), *Alnus*, *Betula* (3 species), *Fagus*, *Fraxinus*, *Hicoria*, *Liquidambar*, *Liriodendron*, *Morus* (2 species), *Populus* (7 species), *Pyrus* (2 species), *Quercus* (6 species), *Robinia*, *Salix*, *Tilia*, and *Umbellularia*. Of coniferous hosts he mentions eight species in four genera: *Abies* (3 species), *Picea* (2 species), *Pseudotsuga*, and *Tsuga* (2 species).

In 1914 he added to this list *Abies balsamea*, *Acer rubrum*, *Betula lenta*, *B. nigra*, *B. papyrifera*, *Crataegus coccinea*, *Nyssa sylvatica*, *Populus alba*, *P. fremontii wislizeni*, *P. heterophylla*, and *Quercus pagodaefolia*. Farlow and Seymour¹⁰ also list *Acer nigrum*. White¹¹ supplements the list with *Aesculus hip-*

⁸ The structure of the spore wall in *Ganoderma*, in *Bot. Gaz.* 83 (1927) 48-60, pl. 5.

⁹ Notes on some diseases of trees in our national forests, II. in *Phytopathology* 2 (1912) 75-76.

¹⁰ A provisional host index of the fungi of the United States (1888-91) 166.

¹¹ *Trans. Roy. Canad. Inst.* (1919) 136.

pocastanum, *Carpinus caroliniana*, *Gleditsia triacanthos*, *Populus alba*, *Populus nigra* var. *italica*, *Pyrus aucuparia*, *Quercus velutina*, *Ulmus americana*, and varieties of cultivated *Prunus*. Baxter¹² adds *Morus rubra*.

The latest summary is that of Seymour¹³ in which are given the following hosts for *applanatum* on the North American continent: *Acer macrophyllum*, *negundo*, *rubrum*, *saccharinum*, *saccharum*, *saccharum* var. *nigrum*, *spicatum*; *Acacia* sp.; *Aesculus hippocastanum*; *Alnus oregana*; *Baccharis halmifolia*; *Betula alba* var. *papyrifera*, *lenta*, *lutea*, *nigra*, *occidentalis*, *populifolia*; *Carpinus caroliniana*; *Carya* [*Hicoria*] *ovata*; *Crataegus coccinea*; *Eucalyptus* sp.; *Fagus grandifolia*; *Fraxinus americana*; *Gleditsia* sp.; *Liquidambar styraciflua*; *Liriodendron tulipifera*; *Morus alba*, *rubra*; *Nyssa sylvatica*; *Platanus occidentalis*; *Populus acuminata*, *alba*, *angustifolia*, *balsamifera*, *deltoides*, *grandidentata*, *heterophylla*, *nigra* var. *italica*; *tremuloides*, *trichocarpa*, *wislizeni*; *Prunus avium*; *Pyrus malus*; *Quercus agrifolia*, *alba*, *coccinea*, *emoryi*, *falcata*, *macrocarpa*, *palustris*, *velutina*; *Rhododendron* sp.; *Robinia pseudo-acacia*; *Salix fragilis*, *nigra*; *Schinus molle*; *Tilia americana*; *Ulmus americana*; *Umbellularia californica*; *Abies concolor*, *grandis*, *lasiocarpa*, *shastensis*; *Picea canadensis*, *engelmanni*, *rubra*, *sitchensis*; *Pinus strobus*; *Pseudotsuga taxifolia*; *Tsuga canadensis*, *heterophylla*. For *Ganoderma australe* he records *Artocarpus communis*; *Prunus occidentalis*, *Prunus* sp. (prune); for *Ganoderma lobatum*, *Quercus rubra*; and for *Ganoderma tornatum*, *Cocos nucifera*; *Quercus agrifolia*.

Boyce¹⁴ considers *Ganoderma applanatum* second only to *Fomes pinicola* in the destruction of wind-thrown coniferous timber on the Olympic Peninsula, Washington.

The senior author has collected the fungus in America on many of the above hosts and in addition on *Fraxinus nigra*, *Quercus lobata*, and *Coccolobus* sp. In the mines around Ironwood, Michigan, it produces a very destructive decay of maple (*Acer*), birch (*Betula*), and hemlock (*Tsuga canadensis*) props, particularly those of *Acer saccharum*. In the coal mines near Seattle, Washington, it is also found on western hemlock props (*Tsuga heterophylla*).

¹² Am. Journ. Bot. 12 (1925) 567.

¹³ Host index of the fungi of North America (1929).

¹⁴ U. S. Dept. Agr. Techn. Bull. 104 (1929) 27.

In England Rea¹⁵ reports it on beech (*Fagus*), oaks (*Quercus*), ashes (*Fraxinus*), limes (*Tilia*), and elms (*Ulmus*).

In France Bourdot and Galzin¹⁶ record it on *Quercus*, *Populus*, *Robinia*, *Fraxinus*, *Juglans*, *Fagus*, *Prunus* (cherry), *Pyrus* (apple), *Corylus*, *Abies*, and *Larix*. Patouillard¹⁷ reports it on the Judas tree (*Cercis siliquastrum*). In addition Nicolas¹⁸ records *Carpinus betulus*, *Alnus*, *Acer dasycarpum*, *Aesculus hippocastanum*, *Tilia cordata*, *Pinus silvestris*, *Abies*, *Morus*, cotton, and palms.

In Spain Lazaro¹⁹ reports it on buttresses of *Fagus*, *Quercus*, and *Fraxinus*.

In Flora Italica Cryptogama Pars I: Fungi, Fasc. 15, pp. 1009–1012, it is reported on various frondose trees, rarely conifers, with specific mention of *Morus alba* and *Fagus*.

Lind²⁰ finds it in Rostrup's herbarium from *Populus deltoides*, *Fagus silvatica*, *Tilia europaea*, *Salix alba*, *Corylus avellana*, *Pyrus communis*, and *Fraxinus excelsior*.

From Japan and Formosa the senior author has specimens collected from *Acer palmatum*, *Alnus formosana*, *Fraxinus* sp., *Quercus serrata*, and *Nephelium longana*. Hennings²¹ also reported *Fomes australis* on *Zellkova acuminata* in Japan.

In South Africa van der Bijl²² reports *Ganoderma applanatum* on *Acacia mollissima*, *Albizia fastigiata*, *Celtis kraussiana*, *Curtisea faginea*, *Olea laurifolia*, *Podocarpus* sp., *Pyrus communis*, and *Rhus laevigata*.

To these hosts are added *Cunonia capensis* and *Trichocladus* sp. in another paper²³ published the same year.

In a government report on plant diseases in northwest Africa published in 1921 Steeg²⁴ reports it from Algeria on the carob tree (*Ceratonia siliqua*).

¹⁵ British Basidiomycetae (1922) 597.

¹⁶ Hyménomycètes de France (1928) 611.

¹⁷ Le genre *Ganoderma*, in Bull. Soc. Myc. Fr. 5 (1889) 67.

¹⁸ Bull. Soc. Myc. Fr. 42 (1926) 190.

¹⁹ Las Polyporaceos de la flora Española (1917) 90.

²⁰ Danish fungi as represented in the herbarium of E. Rostrup (1913) 383.

²¹ Engl. Bot. Jahrb. 28 (1900) 268.

²² South Afr. Journ. Sci. 18 (1922) 278–279.

²³ Kew Bull. Misc. Inf. 6 (1922) 178.

²⁴ [Gouv. gén. Algérie] Exposé situation gén. Algérie (1921) 512–514; Exp. Sta. Rec. 49 (1923) 45.

Weir²⁵ found *australe* once as a wound parasite on *Hevea brasiliensis* in the Amazon Valley.

Cunningham²⁶ reports *applanatus* on fallen logs of *Podocarpus spicatus* and *Dacrydium cupressinum* in New Zealand, while *australe* is found on *Acacia dealbata*, *Coprosma lucida*, *Nothofagus fusca*, *N. menziesii*, *Podocarpus spicatus*, and *Salix baby-lonica*. He finds *subtornatus* on *Dacrydium* and *Podocarpus*.

The above list comprises over fifty genera and over one hundred species of trees for the temperate regions alone. When one considers the tropical and subtropical regions, with their thousands of species of trees on many of which collections of *Ganoderma applanatum* and its varieties or close relatives have been made, in numerous instances without identification of the host, the great variety of plants attacked by this ubiquitous wound parasite and saprophyte will be appreciated.

PARASITISM OF GANODERMA APPLANATUM AND ITS VARIETIES

While the fungus is usually found as a saprophyte on stumps and fallen and standing trunks it is recognized at times as a parasite that gradually invades the living sapwood after entering through wounds and becoming established in the heartwood.

In 1906, Heald²⁷ called attention to its attack on *Populus deltoides*, considering it a facultative parasite that is not able to attack young healthy trees but can become parasitic on older trees, whose vitality has become lowered, or those that have reached their maximum development.

Petch²⁸ states that a large *Zizyphus xylopyra* was attacked by *Fomes australis* at Peradeniya and that most of the old trees of *Acacia decurrens* at Hakgala were killed by the same fungus.

Butler²⁹ mentions a root disease of coffee associated with *Fomes australis* in Madras.

Petch³⁰ likewise reports the parasitism of *Fomes applanatus* on *Acacia*, coffee, and tea roots in Ceylon. His observations on the fungus as a cause of tea disease are summarized in Diseases of the Tea Bush (1923) 167-169.

²⁵ U. S. Dept. Agr. Bull. 1380 (1926) 17.

²⁶ Trans. N. Zeal. Inst. 58 (1927) 214-218.

²⁷ A disease of the cottonwood due to *Elfvigia megaloma*, in Nebr. Agr. Exp. Sta. Ann. Rept. 19 (1906) 92-100.

²⁸ Circ. and Agr. Journ. Roy. Bot. Gard. Ceylon 5 No. 10 (1910).

²⁹ Ann. Rept. Board Sci. Advice India 16 (1915) 110.

³⁰ Trop. Agriculturalist 59 (1922) 248.

Steinmann,³¹ on the other hand, finds it almost exclusively saprophytic in the Dutch East Indies.

Kauffman³² cites *Fomes applanatus* as occurring on living *Fagus*, *Fraxinus*, *Quercus*, and *Ulmus*.

Stewart³³ in 1918 found two large cherry trees in New York severely attacked.

Clinton³⁴ discusses the fungus in relation to ornamentals and says that it is occasionally found on living maples, poplars, willows, apples, and peaches.

Hubert³⁵ states that it sometimes occurs on box elder (*Acer negundo*) in association with the red stain caused by *Fusarium negundi* Sherb.

Meinecke³⁶ describes the rot that it produces in *Populus tremuloides* in Utah, but says that *Fomes igniarius* is of far greater economic importance in this species.

Zeller³⁷ observed the progress of root rot in prune trees in Oregon for two years where he found a large number of trees blown over while in full leaf and some in full fruit. All had the characteristic white butt rot of *Fomes applanatus*. About one and a half years later many other trees in the orchard bore fruiting bodies on the lower portion of the trunks and on the roots. These trees had a very loose footing. The infection was thought to occur near the base of the trunk, or on shallow roots, through wounds probably caused by cultivation machinery.

Cleland and Cheel³⁸ state that the appearance of brackets of *Fomes applanatus* at the base of a tree is a sure indication that vital processes are being interfered with. In the forests of New South Wales the fungus is common at the base of *Eucalyptus*. It is also reported as killing a tree of *Acacia horrida* at Sydney.

White³⁹ states that in eastern Canada living trees of almost all the common broad-leaved species have been found bearing sporophores of *Fomes applanatus*, the percentage being high in

³¹ De Thee 7 (1926) 87; Rev. Appl. Myc. 6 (1927) 514.

³² Nineteenth Ann. Rept. Mich. Acad. Sci. (1917) 151-153.

³³ N. Y. Agr. Exp. Sta. (Geneva) Bull. 463 (1919) 172-173.

³⁴ Conn. Agr. Exp. Sta. Bull. 263 (1924) 191.

³⁵ Journ. Agr. Res. 26 (1923) 449.

³⁶ U. S. Dept. Agr. Techn. Bull. 155 (1929) 5.

³⁷ Mycologia 14 (1922) 181.

³⁸ Disease in forest trees caused by the larger fungi, Forestry Commission N. S. W., Bull. 12 (1918) 10.

³⁹ Trans. Roy. Canad. Inst. (1919) 161.

some localities. A study of the disease in an apple trunk showed it to have progressed outward to the bark, involving the cambium. Other trees showed the sapwood invaded. His best argument for parasitism is the presence of a brown band of so-called wound gum and the development of abundant tyloses at the advancing margin of the decay, indicating that the tissue invaded is living. Direct proof of strong parasitism, however, was not forthcoming from several hundred inoculations in six species of healthy trees of different age classes.

Among the monocotyledons the oil palm (*Elaeis guineensis*) is attacked on a large scale in St. Thomas and Princes Islands and the adjoining coast of West Africa. According to Maublanc and Navel⁴⁰ the trees become hollowed at the base for one-third to one-half the thickness of the trunk and to a height of a meter or more. Many of the hollow trees show no external signs and remain in full vigor and production. The palms that fall, however, are always more than 10 meters high.

In 1922 Coutinho⁴¹ again reports it on *Elaeis* and also on *Cocos nucifera* in St. Thomas; da Camara and Coutinho further refer to it in 1925, while De Wildeman⁴² reports *australe* on *Elaeis* from the Congo.

Small⁴³ mentions the fungus as a suspected parasite on coco palm. Von Schrenk and Spaulding,⁴⁴ considered *Fomes applanatus* as a sap-rotting organism. After discussing Heald's paper on the disease of cottonwood they state they are "not inclined to call this decay a disease in the sense in which the decays induced by *Fomes ignarius*, *F. fraxinophilus*, and others are diseases. There are a large number of species of fungi that, like *Fomes applanatus*, grow on dead wood, and that may now and then grow on living trees." They, therefore, considered it a saprophytic form.

⁴⁰ Sur une maladie du palmier à huile (*Elaeis guineensis* Jacq.) aux îles San Thomé et de Principe produite par un champignon (*Ganoderma applanatum* Pers.), in *L'Agronomie Coloniale* 5 (Année 4) (1920) 187-191.

⁴¹ Anais do Inst. de Agron. [Coimbra] (1922); Rev. Appl. Myc. 2 (1923) 589; Anais do Inst. de Agron. [Coimbra] (1925) 138; Rev. Appl. Myc. 5 (1926) 149-150.

⁴² Matières grasses 13 (1921) 5737; Rev. Appl. Myc. 1 (1922) 78.

⁴³ Yearbook Dept. Agr. Ceylon (1927) 7-10; Rev. Appl. Myc. 6 (1927) 273.

⁴⁴ Diseases of deciduous forest trees, U. S. Dept. Agr. Bu. Pl. Ind. Bull. 149 (1909) 58-60.

Hedgcock ⁴⁵ followed this view in 1912, but in 1914 concluded that the fungus "very frequently attacks both the sapwood and heartwood of many living trees."

The evidence presented above, much of which has been corroborated by the senior author points clearly to its parasitic tendencies. The fact that young vigorous trees are not infected is no direct criterion of parasitism, since this is true of all the recognized wound parasites.

MATERIAL EXAMINED

The Philippine material examined is contained in the Bureau of Science herbarium at Manila and the Baker herbarium at the College of Agriculture, Los Baños, the latter being kindly placed at our disposal by Dr. G. O. Ocfemia. The Philippine Bureau of Forestry has also supplied a considerable number of specimens that will be deposited at the Bureau of Science. During the past four years the senior author has likewise made extensive collections for the Bureau of Science so that the material formerly available has been more than doubled. These later collections were always made with the object of securing all variations possible, from the youngest to mature, or even old, stages of development. They have thrown much light on existing relationships and have enabled us to interpret to better advantage the named specimens in the two herbaria.

There are very few extra-Philippine specimens either at Manila or Los Baños. The senior author's herbarium, however, contains considerable material from the United States, Brazil, Japan, and Formosa. Two specimens were secured from the acting mycologist, mycological division, Department of Agriculture, Peradeniya, Ceylon, in a collection of sixteen duplicates of polypores from that herbarium. From the Botanic Gardens, Singapore, E. J. H. Corner, Esq., assistant director, loaned us all their specimens of *Ganoderma*, among which were twenty-two specimens pertaining to the *applanatum* group. From the Botanic Gardens, Buitenzorg, Java, Mr. Beaumée, assistant director, furnished, on loan, one hundred twenty-two specimens of *Ganoderma* or other *Polyporaceae*, including twenty-one collections of the group under review. In addition Dr. J. B. Cleland has furnished the senior author from time to time with a good representative series from Australia. To these institutions and these gentlemen we desire to express our deep appreciation for the courtesies extended.

⁴⁵ *Phytopathology* 4 (1914) 185-186.

The Philippine specimens at the Bureau of Science and in the Baker herbarium have been named principally by Bresadola, Lloyd, Murrill, and Patouillard. These specialists are far from agreement in their species concepts as well as in their identification of the same specimens. The last revision of the Bureau of Science material was by Lloyd, with the result that certain packets bear three different specific names, those of Bresadola, Murrill, and Lloyd. The Los Baños material was largely identified by Lloyd and Patouillard, but apparently Lloyd did not revise any of Patouillard's work. Had he done so his concepts would certainly have differed from those of the French mycologist.

Unfortunately, many of the earlier collections preserved in the Philippines are limited in quantity and are often represented merely by a portion of a small specimen. Also a considerable number of the specimens reported by various writers are missing. Collectors for the Bureau of Science have also often been remiss in keeping separate the different individuals of a given collection, with the result that in a number of instances at least two distinct species of *Ganoderma* have been included in the same packet. In as much as the original collections have often been split up and distributed widely as duplicates it is quite probable that different herbaria have not always received the same species, variety, or form as in the original packet in Manila. In a few instances this has been found to be the case with supposedly duplicate specimens sent to the Baker herbarium at Los Baños.

In the course of the investigations approximately three hundred eighty collections within the group were critically examined and compared both microscopically and macroscopically. These came from the following countries: North America, 43; South America, 9; West Indies, 2; Canary Islands, 1; Europe, 4; Africa, 2; Australia, 14; New Zealand, 1; Dutch East Indies, 16; Ceylon, 2; Borneo, 4; Federated Malay States, 20; Amboina, 1; China, 3; Formosa, 5; Japan, 11; Philippine Islands, 250.

This is probably the largest series of specimens ever critically studied at the same time, one in comparison with the other, but there still remains much more to do both in the Philippines and in other of the less-explored regions before a complete rational monographic treatment can be accomplished. The present is but a stepping stone.

TECHNIC

All microscope measurements of hyphæ and spores were made with the 1/12a fluorite oil-immersion objective and 10x Huyghenian ocular, using a Leitz microscope, with a tube length of 160 millimeters, while colors of these elements were observed with the No. 6 (4 millimeter) objective and the same ocular. All photomicrographs of spores were made with the 1/12a oil immersion objective and 8x ocular. For each specimen ten representative spores in the crushed mount, or from the upper surface of the pileus, were measured and the average taken. Similarly, ten measurements were made of both the context and dissepiment hyphæ. Sometimes two or more specimens from the same collection were examined in this way, and very often the spores from the crushed mount and from the upper surface of the same sporophore were studied. All microscopic mounts were made in 7 per cent potassium hydrate. In the case of crushed mounts a generous fragment of pores was first saturated with the potash then cut up somewhat and pressed. Spores from the upper surface were removed in a loop of fine flamed platinum wire dipped in the potash solution. The former method naturally yielded considerable fine débris, which was objectionable in photographing; the latter method, which was followed whenever spores adhered to the upper surface, frequently gave nearly clean mounts. In the many comparisons made between spores from the crushed pores and those from the surface of the specimen they were always found to be the same, varying only in the latter being more mature and, therefore, usually being somewhat larger and darker colored. We have found the method so satisfactory that it is being applied to other species of *Ganoderma*.

In all, about 8,700 hyphal measurements and 4,700 spore measurements were made during the study; over two hundred photomicrographs of spores were taken. For the latter either the Zeiss "Maccam" or the small Bausch and Lomb camera was used. These have a fixed bellows length and yield very nearly the same magnification.

A few photomicrographs of somewhat higher magnification to show the structure of the crust and the dissepiments were taken on the large Bausch and Lomb horizontal camera, using a Zeiss microscope equipped with dry objective DD and ocular 4. These are all at the same magnification.

Pore surfaces of representative specimens were photographed through a 35-millimeter Zeiss Planar lens fitted to a Leitz microscope with 6x ocular and 160-millimeter tube length.

In addition to photographing the pores, representative specimens were selected to show variation in their size and shape and variation in thickness of dissepiments. The size was recorded in two ways; namely, by measuring the number per millimeter with a hand magnifier and celluloid millimeter scale, and by actual measurement of the diameter of the pores and the thickness of the pore walls under the low power of the microscope.

Colors were compared with those in Ridgway's Color Standards and Color Nomenclature, and all direct comparisons are indicated by (R) following the color name. It must be borne in mind, however, that spore colors as viewed through a microscope are very difficult to match and even color variations in the context or of the upper and lower surfaces of the sporophores cannot be reported with any great fidelity since the incidence of the light, the intensity of illumination, and the lack of exactly corresponding shades in the book all influence the results obtained. It is believed, however, that those recorded will offer a fairly close approximation and the ranges will give an idea of the variations to expect.

DISCUSSION OF DESCRIBED SPECIES

There have been a considerable number of specific names in current use within the group but their application has been far from consistent. Before a definite opinion concerning certain of them regarding their validity as species, varieties, or forms can be formed, however, it will be necessary to examine such of the types as have been preserved. Since there is no opportunity of doing this at present the only procedure that can be followed is to discuss them in the light of determinations and opinions expressed by other workers.

Fourteen specific names have been applied to *Ganoderma applanatum* or its variants in the Philippines; namely, *applanatum*, *australe*, *fasciatus*, *gibbosum*, *incrassatum*, *koningsbergii*, *leucophaeum*, *mastoporum*, *megaloma*, *nigro-laccatum*, *oroflavus*, *subtornatum*, *testaceum*, and *tornatum*. Such of the specimens so determined as are referable to the *applanatum* group at all are nothing but varieties or forms of the base species. The following comments are offered on those not treated under the later discussion of accepted species and varieties.

FOMES FASCIATUS LÉV.

Fomes fasciatus Lév. (bis), *Bureau of Science* 28450 of Lloyd's determinations, is more closely allied to *Ganoderma mastoporum* (Lév.) than to *G. applanatum*, while *Bur. Sci.* 28308 is a very young sessile specimen without pores that we have referred to *G. applanatum* var. *philippinense*. He has also named one specimen in the Singapore collections (8354) that is typical *tornatum*. Lloyd⁴⁶ discusses the fungus as follows: "With characteristic spores. It has a hard non-laccate crust, ungulate in shape, yellowish pore mouths and little context development, I should call it a form of *Fomes australis*. It is *Fomes fasciatus* in the sense of Lévillé and Patouillard, though as it was only a misdetermination of Lévillé I think the name has no validity as applied to this plant." Later⁴⁷ he states, "Surface dull, marked with pale and brown zones, otherwise as the form *leucophaeus*. The spores of our Java collections are none of them truncate at the base, the membrane seeming not so strongly developed as usual. This is a tropical form the name based on a misdetermination by Lévillé. We do not think that an acknowledged misdetermination has any validity as a name, but use it as we know no other for this form."

His last word on the subject⁴⁸ is this: "Certainly only a form of the polymorphic *Fomes applanatus*. It is what Lévillé called *Fomes fasciatus* (in duplicate) but these forms are hard to definitely name. It should be renamed if these forms were worth renaming."

There is one specimen (1926) in the Javan collections named by Patouillard (Plate 5, figs. 17 and 18). This is a young sub-ungulate sporophore with a rather hard auburn context and a thin layer of young pores from which we could obtain no spores. It is sufficiently close to *applanatum* to be considered merely a variant.

Torrend⁴⁹ considers the fungus a variety of *G. applanatum*.

GANODERMA GIBBOSUM (NEES)

There are five Philippine collections referred here by Lloyd. Of these, 5110 and 19234 are typical sessile *applanatum* var. *tornatum*, 9100 and 10534 are very young specimens without pores,

⁴⁶ Letter 38 (1911) 5.

⁴⁷ Syn. Gen. *Fomes* (1915) 265.

⁴⁸ Myc. Notes 71 (1924) 1242.

⁴⁹ Les Polyporacées du Brésil, in *Broteria* 18 (1920) 40.

which are better referable to *G. mastoporum*, and Copeland 762 is the cotype of *Ganoderma incrassata* forma *substipitata* Bres. This latter appears close to *tornatum* but is not included in the present paper.

There are three specimens named *gibbosum* by Lloyd in the Singapore herbarium. Of these, one (5385) may be a small stipitate form of variety *philippinense*, another (5518) is *mastoporum*, and the third (5384) is an irregular form that we are unable to properly refer at present.

Lloyd⁵⁰ states that small stipitate Brazilian specimens sent him by Rick were referable here but that they are really *Fomes applanatus*. Later⁵¹ he also reports in connection with Javan specimens from van Overeem, "This is the name applied to the polymorphic *Fomes applanatus* when it takes stipitate forms as it does in the tropics, but rarely in temperate regions. It is not a species." Junghuhn⁵² merely gives Nees' description and states that the fungus had not been observed by him. Cooke⁵³ places it as a synonym of *Fomes amboinensis* Fr.

Bresadola⁵⁴ describes var. *pulchella* from Zollinger's collection from Java, stating that it differs from the type in its smaller size and smaller spores. The spores are given as smooth, 4 to 6 by 6 to 9 μ , while in typical *G. gibbosum* they are said to be 6 to 7 by 9 to 11 μ .

Patouillard⁵⁵ in his last posthumous work places the species as variety *stipitatum* of *Ganoderma applanatum*.

GANODERMA INCRASSATUM (BERK.)

This was originally described⁵⁶ from Cape York, Australia (*Challenger Exped.* 141). We find no further notes regarding it in the literature except that Cooke⁵⁷ reports *Fomes reniformis* Morg. as a synonym. If this were the case then *incrassatum* would become in turn a synonym of *lobatum* Schw. Lloyd⁵⁸ considers it the same as *leucophaeus*.

⁵⁰ Myc. Notes 59 (1919) 859.

⁵¹ Myc. Notes 71 (1924) 1242; see also 67 (1922) 1165.

⁵² Praemiss. Fl. Crypt. Javae Insulae (1838) 66.

⁵³ Praecursores ad monographia Polypororum, in Grev. 15 (1886) 55.

⁵⁴ Polyporaceae Javanicae, in Ann. Myc. 10 (1912) 501.

⁵⁵ Ann. Crypt. Exot. 1 (1928) 17.

⁵⁶ Journ. Linn. Soc. (London), Bot. 16 (1877) 41.

⁵⁷ Grevillea 15 (1885) 21.

⁵⁸ Syn. Gen. Fomes (1915) 281.

In his preliminary survey of the Polyporaceæ Murrill⁵⁹ says that when *reniformis* [*lobatum* (Schw.) Atk.] was first sent to Kew it was determined as *applanatum*. Later it was placed by Cooke under *incrassatus*. The specimen, however, was not in his opinion, representative of *reniformis*. This is perhaps what led Cooke to consider it the same as *incrassatus*.

Bresadola⁶⁰ based his new form *substipitata* on *Copeland* 762. In the Bureau of Science herbarium this is a small stipitate specimen with a blunt, nearly vertical, sulcate margin, which is rather close to *tornatum* but seems sufficiently distinct to maintain until further material is collected. In the Baker herbarium there is a sessile specimen with a rather acute margin under the same number.

There are in the Bureau of Science three specimens from J. A. Stevenson of which two (1599, 1690b) are from Florida determined by Weir as *G. incrassata* and *G. tornata*, respectively, and one from Porto Rico (1480) determined as *G. tornata*; also, the senior author has a section of a sporophore from the New York Botanical Garden collected in Florida and determined by Murrill. These are the same heavily laccate species but apparently are not *incrassatum*. The evidence at hand, therefore, is not sufficient to interpret *Ganoderma incrassatum* of Berkeley.

FOMES KONINGSBERGII LLOYD

The species was described⁶¹ from an abundant collection from Java sent to Lloyd by Dr. J. C. Koningsberger. In the Bureau of Science there is a single specimen (*Flora of British North Borneo* 2094) so named by Lloyd. This is quite typical of what the senior author calls variety *philippinense* of *Ganoderma applanatum*. Among the Buitenzorg specimens there is one collection (1619) also named by Lloyd (Plate 20, figs. 9 and 10). This is sufficiently typical of what the senior author segregates as variety *tornatum* forma *macrospora*.

GANODERMA LEUCOPHAEUM (MONT.)

Described⁶² from Ohio, collected by Sullivant.

⁵⁹ Bull. Torr. Bot. Club 30 (1903) 299.

⁶⁰ Hedwigia 56 (1915) 295.

⁶¹ Syn. Gen. Fomes (1915) 270.

⁶² Sylloge Generum Specierumque Cryptogamarum (1856) 157-158.

Patouillard⁶³ recognized it as a species growing in France and Bresadola has reported it from Hungary⁶⁴ and Africa.⁶⁵ Theissen found it in Brazil,⁶⁶ Cleland and Cheel in Australia,⁶⁷ and the senior author found it in Japan. These few references indicate that the form is practically coexistent with *Ganoderma applanatum*.

In his critical study of *Fomes applanatus* in the United States Atkinson⁶⁸ has conclusively shown that it is nothing but a variant of that species. Bresadola and Patouillard always maintained the fungus as a distinct species. Lloyd in his earlier writings⁶⁹ considered it distinct from *applanatum* but finally concluded⁷⁰ that it is "only a form of the common *Fomes applanatus* with a pale hard crust." Cleland and Cheel⁷¹ place it as a variety of *applanatum*.

The senior author has collected *Fomes applanatus* in various parts of the United States over a hundred times and has observed it growing thousands of times, as it is very common particularly in the northern part of the country, and can affirm that the variation called *leucophaeum* is by no means extreme and hence readily falls within the species concept of *applanatum*. Many of the Philippine specimens in the Baker herbarium so determined by Patouillard the senior author would refer to *applanatum* var. *philippinense*, as they appear varietally distinct from any forms seen in the United States or from Europe. Lloyd's *leucophaeum* of the Philippines is largely referable to *applanatum*, although a few go into variety *philippinense*, while specimens so named in the Buitenzorg and Singapore herbaria are principally *tornatum*.

⁶³ Bull. Soc. Myc. Fr. 5 (1889) 73.

⁶⁴ Hymenomycetes Hungarici Kmetiani, in Atti dell. I. R. Acad. Sci. Let. ed Arti degli Agiati in Rovereto III 3 (1897) 66-117.

⁶⁵ Fungi Kamerunenses, in Bull. Soc. Myc. Fr. 6 (1890) XLI.

⁶⁶ Polyporaceae austro-brasilienses imprimis Rio Grandenses, in Denkschr. math.-nat. Kl., Kaiserl. Akad. Wiss. (Wien) (1911) 6 (of reprint).

⁶⁷ Proceed. Roy. Soc. N. S. W. 51 (1918) 518.

⁶⁸ On the identity of Polyporus "applanatus" of Europe and North America, in Ann. Myc. 6 (1908) 179-191.

⁶⁹ Myc. Notes 6 (1901) 60 (Note 135); Letter 10 (1906) 3-4; Letter 26 (1909) 4; Myc. Notes 33 (1913) 437.

⁷⁰ Myc. Notes 67 (1922) 1164; 71 (1924) 1242.

⁷¹ Proceed. Roy. Soc. N. S. W. 51 (1918) 518; Trans. Roy. Soc. So. Austral. 47 (1923) 68; ibid. 48 (1924) 251.

GANODERMA MASTOPORUM (LÉV.)

This is a good but apparently highly variable species which forms the nucleus of a group sufficiently distinct from the *applanatum* assemblage. It has been given at least twelve different names in the Philippine collections; namely, *amboinense*, *applanatum*, *australe*, *balabacense*, *dorsale*, *fasciatus* Lév., *gibbosum*, *mangiferae*, *nigro-laccatum*, *testaceum*, *tornatum*, and *williamsianum*. The senior author considers *Ganoderma mastoporum* Lév. more closely allied to the true laccate *Ganodermas* and hence it is not described in the present paper. At one extreme of its variation it approaches forms of *applanatum* var. *philippinense*. It has essentially the same type of spore as this variety but is a much smaller species and strongly tends to stipitate or substipitate forms.

GANODERMA MEGALOMA (LÉV.)

This was described by Lévillé⁷² from a New York collection at the Muséum d'Histoire naturelle de Paris. He states that it is close to *applanatum* in form, consistence, and size, but differs from it essentially in the color of the pileus, the pores, and especially in the margin, which forms on the lower surface a sterile band up to 0.5 centimeter wide. It is interesting to note, however, that *Fomes applanatus* from Ménand, New York, is listed in the same paper just preceding his new species.

Murrill⁷³ took up the specific name in 1903 and applied it generally to what is now considered *Fomes applanatus* of the United States. He continued this usage in the North American Flora (Polyporaceæ), 1908, the same year that Atkinson⁷⁴ had shown the identity of the two. Bresadola⁷⁵ maintained the species as *Ganoderma megaloma* (Lév.) Big. and considered *leucophaeum* a synonym. He cites two collections from the Philippines. One of them (*Bur. Sci.* 10538) the senior author would refer to *applanatum* var. *philippinense*; the other is not represented in the herbarium.

⁷² Ann. Sci. Nat. II Bot. 5 (1846) 128-129.

⁷³ Bull. Torr. Bot. Cl. 30 (1903) 271.

⁷⁴ Ann. Myc. 6 (1908) 179-191.

⁷⁵ Hedwigia 53 (1912) 54; Synonomia et adnotanda mycologia, in Ann. Myc. 14 (1916) 225.

Lloyd ⁷⁶ states that "no type exists and it is unknown" and made no use of the name.

There can be little question that the fungus is but a form of the variable *applanatum*. Atkinson ⁷⁷ and White ⁷⁸ both discussed the wide sterile band on the lower surface of the margin and showed that it is nothing specific in character. The writers would also place the species as a direct synonym of *applanatum*.

GANODERMA NIGRO-LACCATUM CKE.

Described by Cooke ⁷⁹ from Mauritius. Bresadola ⁸⁰ reported it from Kamerun in 1890 with the remark that the specimens examined closely resembled *Polyporus fuliginosus* Scop. (*benzoi-neus* Fr.) but differed in the glabrous nigro-laccate crust. Later ⁸¹ he placed the species in synonymy with *applanatum*, with the statement that there are two specimens in Herb. Kew from Mauritius under 2 (cited in the original description), one of which is *Ganoderma galegense* (Mont.). Lloyd ⁸² remarked in 1912, "For me a form of the common *Fomes australis* of the tropics, with a slightly laccate crust." Ten years later ⁸³ he states, "quite different from *Fomes applanatus* in having a more or less black lacquer, it is still much closer to *Fomes applanatus* than it is to those of the *lucidus* group. We take it in the only logical sense of Cooke's name even if the author had no idea, however vague, of its identity." Cleland and Cheel ⁸⁴ place it as a variety of *applanatum*. Cunningham ⁸⁵ states that it "cannot be separated on any character from *F. australis*."

There are three specimens in the Bureau of Science and Baker herbaria determined by Lloyd, of which one (*Baker 9683*) is referable to variety *tornatum*; the other two are in the Bureau of Science (*14366* and *19084*). These are the same as two other specimens in the Baker herbarium, *898* determined *Ganoderma amboinense* (Lam.) Pat. by Patouillard and *9707* deter-

⁷⁶ Syn. Gen. *Fomes* (1915) 282-283.

⁷⁷ Ann. Myc. 6 (1908) 179-191.

⁷⁸ Trans. Roy. Canad. Institute (1919) 135, Pl. 2, fig. 1.

⁷⁹ Grevillea 9 (1881) 97.

⁸⁰ Bull. Soc. Myc. Fr. 6 (1890) XLII.

⁸¹ Hedwigia 53 (1912) 55.

⁸² Letter 39 (1912) 2.

⁸³ Myc. Notes 67 (1922) 1165; see also Syn. Gen. *Fomes* (1915) 265.

⁸⁴ Proc. Roy. Soc. N. S. W. 51 (1918) 519; Trans. Roy. Soc. So. Austral. 47 (1923) 68.

⁸⁵ The Polyporaceae of New Zealand, in Trans. N. Zeal. Inst. 58 (1927) 217.

mined by Lloyd as *Fomes gibbosus* Nees. They are, in the senior author's opinion, more closely related to *Ganoderma mastoporum* than to any other species. It is, therefore, perhaps better to follow Bresadola's disposition of the matter and consider *nigrolaccatum* as a synonym of *applanatum*.

GANODERMA OROFLAVUM (LLOYD)

The first mention of this fungus was in Lloyd's determination of specimens sent by Henri Perrier de la Bathie, Madagascar,⁸⁶ in which he records, "*Fomes australis* Fr. As we are calling this form ad interim until the 'applanatus' group is revised. In the end this very distinct form with *yellow pore* mouths will have a distinct name probably. We have labelled it *Fomes oroflavus*." He includes it as *Fomes oroflavus* in his Synopsis of the Genus *Fomes* (1915) 265, with the statement that it is "a tropical form of *Fomes applanatus* with *yellow pore* mouths," etc., and cites specimens collected by Wilson in Australia and Forbes in Hawaii. In 1922 he⁸⁷ reports the fungus from the Philippines, likewise as a form of *applanatus*. In 1924, he reports it⁸⁸ from California and says that *Fomes brownii* (Murr.) is the same. Cleland and Cheel⁸⁹ in 1918 record the fungus from New South Wales and Nauru Island under the name *Fomes applanatus* var. *oroflavus*. Van der Bijl⁹⁰ records it from South Africa as *Fomes oroflavus* Lloyd and gives a description of his single collection. He adds the following remarks, "Except for the yellow pore mouths this plant is like *Fomes applanatus*. So far I have only seen the above recorded specimen and it is evidently not common. If it is merely a variation of *F. applanatus* it would appear strange that it should not be more common." Cunningham⁹¹ reports it as *Fomes australis* (Fr.) Cke. var. *oroflavus* (Lloyd) from New Zealand.

There are three Philippine collections of this fungus at the Bureau of Science named by Lloyd. One of them (8734) is a portion of a young entirely resupinate plant of a single year's growth with a mature pore layer, collected at an altitude of 2,100 meters in the Mountain Province, Luzon. The pore surface is now between cinnamon-buff (R) and clay color (R).

⁸⁶ Letter 48 (1913) 8.

⁸⁷ Myc. Notes 67 (1922) 1164.

⁸⁸ Myc. Notes 72 (1924) 1289.

⁸⁹ Journ. of Proc. Roy. Soc. N. S. Wales 51 (1918) 518.

⁹⁰ So. Afr. Journ. Sci. 18 (1922) 278.

⁹¹ Trans. N. Zeal. Inst. 58 (1927) 217.

The spores (Plate 33, fig. 7) are of the size and type of *applanatum*, to which Bresadola properly refers it. No. 36046 consists of portions of two broadly applanate pilei collected in the lowlands of Basilan Island. Both are distinctly tuberculose above, with thin context and relatively long hard pores, the mouths of which are now dark brown. The collection tends toward *tornatum* in one specimen (Plate 14, fig. 5) and toward *applanatum* var. *philippinense* in the other (Plate 14, fig. 6). It is one of those intermediate things upon which individual judgment must be used in classification. The writer prefers to consider it an extreme form of *applanatum* var. *philippinense* since the spores are exactly the same and the tuberculose crust is characteristic of that variety. No. 36097 is a fragment of an old sporophore, bleached within, which for like reasons is included in the same variety. In the Singapore herbarium there is another specimen (8323) determined by Lloyd and this is *Ganoderma williamsianum* Murr.

The character upon which Lloyd bases the species, namely, yellow pore mouths, is unsafe. It is a condition that is common in dried material of *tornatum* and is occasionally present in *applanatum* or its varieties. The fact that *oroflavus* is rarely reported from any particular region but has been recorded from such widely separated places as Japan, the Philippines, Australia, New Zealand, Madagascar, South Africa, Hawaii, and the western United States leads to the belief that it is nothing but a condition of growth, which is not worth segregating even as a form. Lloyd's concept being based on color of pores only does not take into consideration other more important variations that are indicated in the various published descriptions. For one thing it is certain that *Elfvingia brownii* Murr. of California is varietally distinct from any of the other forms or varieties that the writer has encountered and could not be considered synonymous with *oroflavus*.

GANODERMA SUBTORNATUM MURR.

Described from the Philippines by Murrill.⁹² The type having been misplaced at the New York Botanical Garden could not be examined by the writer. The two other specimens (*Elmer 6943* and *7213*) cited by Murrill in the original description, however, have been loaned to us by the Kew herbarium. These appear referable to *G. mastoporum* and do not belong in the *applanatum* group.

⁹² Bull. Torr. Bot. Club 34 (1907) 477.

Bresadola⁹³ named seven specimens from the Philippines for Elmer and the Bureau of Science. Of these, three are not represented in the herbarium (*Copeland 189*, *Elmer 10756*, and *Merrill 3691*). Likewise Graff's⁹⁴ specimen (*Bur. Sci. 16025*), reported as *Ganoderma tornatum* var. *subtornatum* (Murr.) Graff comb. nov., is missing. However, there are four specimens determined by Bresadola and one determination, as well as one confirmation, of Graff available. Four of these are referable to *Ganoderma applanatum* var. *philippinense* and are typical of this common variation. Lloyd calls two of them *australe* [*16634* (Plate 9, fig. 6) and *19239*], but they are entirely different from the senior author's concept of that variety. On the other hand, *Bureau of Science 19234*, determined *subtornatum* by Graff, is *gibbosum* for Lloyd but is good *tornatum*.

Lloyd⁹⁵ reported it from Madagascar in 1913 but later⁹⁶ stated the specimen was not typical. In his Synopsis of the Genus *Fomes* he maintains the species and records six collections from the Philippines sent by Merrill and one each from Java, Madagascar, and New Zealand. There are no specimens in Philippine herbaria, however, that are marked as his determinations. In the Singapore herbarium the name has been applied by Lloyd and others to various things that are mostly variants of the *mastoporum* group. There is also in that herbarium a specimen of *Elmer's Philippine Plants 6916*, which was distributed to Kew as *Elfvigia tornata*. Lloyd named it *subtornatum* but in reality it is *Ganoderma mangiferae* Lév., of which it has the characteristic long spores. When the Philippine collection of Polyporaceae passed through his hands about 1918 he supplied to the Bureau of Science an illustrated manuscript entitled History and Description of Philippine Polypores. This is dated November, 1918. In it he cites *Elmer 7213* and states that it "was named *Polyporus subtornatus* Murr. but is typically *Polyporus mastoporus*." This particular number of which Lloyd had a "frustule" is mentioned in Murrill's original description.

Cunningham⁹⁷ considers *Fomes subtornatus* as one of the three species of the *applanatum* group in New Zealand. His

⁹³ Hedwigia 51 (1911-12) 313; 53 (1912) 55.

⁹⁴ Bull. Torr. Bot. Club 48 (1921) 290.

⁹⁵ Letter 48 (1913) 8.

⁹⁶ Syn. Genus *Fomes* (1915) 269.

⁹⁷ Trans. N. Zeal. Inst. 58 (1927) 218.

illustration conforms well with the writer's conception of *Ganoderma applanatum* var. *philippinense*. His use of pore size as a distinguishing character will be discussed later.

Judging from the original description and the two specimens cited therein, all of which agree well with *G. mastoporum*, it would appear that *subtornatum* is synonymous with that species.

GANODERMA TESTACEUM (LÉV.)

Described by Lévillé from central Brazil.⁹⁸ The description calls for small stipitate specimens of a *testaceo-fuscus* color with an obtuse margin, the stipe being horizontal and appearing to be a prolongation of the pileus. Lévillé remarked that it appears to differ from *Polyporus gibbosus* Nees only in being much smaller and in the shortness of the stipe, which is not oblique but horizontal. The senior author has specimens from Brazil, sent by Father Rick as *Fomes applanatus*, that agree rather closely with the description. Comments will be offered later on these in comparison with the type which has kindly been loaned to us by the Paris Museum. Both Bresadola⁹⁹ and Patouillard¹⁰⁰ maintained the species. Lloyd mentions the fungus only twice,¹⁰¹ as far as descriptive notes are concerned. Speaking of the type he says, "Brazil, Lévillé. Type at Paris a little deformed specimen of *Fomes australis*. Used in this pamphlet in the sense of Patouillard, not Lévillé."

Of the named material available for examination there are two specimens in the Bureau of Science (18388 and 25107) determined by Sydow.¹⁰² In the Baker herbarium there is one specimen (1662) named by Patouillard. No. 18388 is typical *applanatum* var. *philippinense* (Plate 9, figs. 10 and 11); 25107 is a thin young applanate specimen with an acute margin that is intermediate between *applanatum* and *tornatum*, with spores of the former and general habit of the latter. It is not included in the present paper. Baker 1662 has the spores and stipitate to substipitate habit of some forms of *tornatum*, to which we refer it (Plate 19, fig. 5). In this connection it may be worth noting that the senior author has collected on the same log numerous specimens of *tornatum* (50028) ranging from small forms

⁹⁸ Ann. Sci. Nat. III Bot. 5 (1846) 126.

⁹⁹ Ann. Myc. 10 (1912) 501; Hedwigia 56 (1915) 294.

¹⁰⁰ Bull. Soc. Myc. Fr. 5 (1889) 67; Leaflet. Philip. Bot. 6, Art. 104 (1914) 2250; Ann. Crypt. Exot. 1 (1928) 18.

¹⁰¹ Syn. Genus Fomes (1915) 270-271, 285.

¹⁰² Ann. Myc. 15 (1917) 166.

with long irregular lateral stipes to typical sessile applanate forms (Plate 18).

GANODERMA TORNATUM (PERS.)

Described by Persoon from material collected on some island in the Pacific during the voyage of the *Uranie*.¹⁰³ The senior author, however, has not seen the original description. Fries,¹⁰⁴ two years after the publication of Persoon's species, described his *Polyporus australis*, likewise from an island in the Pacific. In 1874 he included the species in his *Hymenomycetes Europaei*¹⁰⁵ and extended its range to southern Europe, citing *P. tornatus* Pers. as a direct synonym. The type of *tornatum* exists at Paris according to Lloyd,¹⁰⁶ who states that L  veill   endorsed it "as being *Fomes australis*." L  veill  , however, although thus recognizing the priority never used the name *tornatus*.

Patouillard used the Friesian species throughout his works, with the broad interpretation that it also occurs¹⁰⁷ in southern Europe, Brazil, Cuba, Tierra del Fuego, New Caledonia, Cochin China, Canada, etc.

There are, however, four specimens in the Baker herbarium determined by him as *tornatum* and one packet marked "*australe* Fr. (*tornatum* Pers.)," indicating that he considered the two synonymous.

In one of his earlier papers Bresadola¹⁰⁸ remarked that he believed that *australe* Fr., which he says is very common in Europe, should be conserved and that *applanatum* Pers., very rare in Europe and better known in Africa, America, etc., should be considered a variety of it on account of the more echinulate spores. He does not seem to have followed this usage in any subsequent work, however. As late as 1911 he¹⁰⁹ used the name *australe* for Philippine material but in 1912 changed to *Ganoderma tornatum* (Pers.) Bres., citing as a synonym "*Ganoderma australe* Bres. hucusque pr. p. at aut. plur. nec Fries."

¹⁰³ Gaudichaud-Beaupr  , Charles, Botanique du voyage autour du monde par ordre du roi sui les corvettes l'*Uranie* et la *Physcienne* pendant les ann  es 1817-1820 par M. Louis de Freycinet. Paris (1826) 173.

¹⁰⁴ Elenchus Fungorum sistens Commentarium in Systema Mycologicum 1 (1828) 108.

¹⁰⁵ *Hymenomycetes Europaei sive Epicriseos Systematis Mycologici*, ed. 2 (1874) 556.

¹⁰⁶ Syn. Genus *Fomes* (1915) 286.

¹⁰⁷ Bull. Soc. Myc. Fr. 5 (1889) 71.

¹⁰⁸ Rev. Mycol. 12 (1890) 104.

¹⁰⁹ Hedw. 51 (1911-12) 313; 53 (1912) 55.

He thus maintains the two species but apparently reserves *tornatum* for the tropical and subtropical regions of the Pacific. *Fomes australis* Fr., he says, is only rarely met with in the Pacific islands adjoining the west coast of America. In another paper ¹¹⁰ published the same year he uses *tornatum* for Javan material with the remark that an examination of the original specimen indicates that *Polyporus australis* Fr. is different from *P. tornatus* Pers., and quite rare, while *P. australis* auctt., on the contrary, pertains to *P. tornatus* Pers., a species met with everywhere in the Tropics.

Lloyd preferred the old usage, but in his later years did not apply *australe* with any degree of consistency, since many Philippine specimens that he should logically have referred to it he placed in *applanatum*. In discussing the "section *Ganodermus*" in the Philippines he ¹¹¹ places them under seven specific names, including both *tornatus* and *australis*. He does not make himself clear, however, as to the characters distinguishing the two.

Bourdot and Galzin ¹¹² include *Ganoderma australe* (Fr.) Pat. as a subspecies occurring in France. They say it is very close to *G. applanatum*, but in general rather easy to distinguish. It certainly is not what has been called *australe* of the eastern Tropics.

Rea ¹¹³ records *G. australe* (Fr.) Pat. for England but his description calls for a fungus "encrusted on the surface with a sticky resinous coating, which dries up into tubercular ridges, and becomes laccate and shining." This seems to be a conception different from that of the French authors.

On the whole it appears that the only logical way to treat the subject is to consider *tornatum* the proper name to apply to Oriental tropical and subtropical specimens formerly placed in *australe* by most authors. Graff ¹¹⁴ has done this and Murrill has also done so in principle, although his interpretation of *tornatum* is very indefinite, many of his determinations being erroneous. He includes it in the North American Flora ¹¹⁵ and other publications as *Elfvigia tornata* (Pers.) Murr., stating that it is "abundant and widely distributed in tropical America;

¹¹⁰ Ann. Myc. 10 (1910) 502.

¹¹¹ Myc. Notes 67 (1922) 1164-1165.

¹¹² Hyménomycètes de France (1928) 612.

¹¹³ British Basidiomycetae (1922) 598.

¹¹⁴ Bull. Torr. Bot. Club 48 (1921) 289.

¹¹⁵ Volume 9 pt. 2 (1908) 115.

also in tropical Asia." It is also recorded in his Tropical Polypores (p. 91) as "extremely common throughout the tropics on decayed logs and stumps." It is mentioned in Southern Polypores (p. 61) that a doubtful specimen was received from Austin, Texas, and in Western Polypores (pp. 29-30) as doubtfully collected on *Quercus agrifolia* and *Umbellularia* near Berkeley, California. These are the hosts of *Elfvigia brownii* Murr., but the description does not seem to apply. He also reports it from Japan ¹¹⁶ with the inference that it is very common there; he apparently has confused it with a form of *applanatum* that is frequently collected in those islands.

The specimens reported as *tornatum* in the published records of Philippine fungi are thirty-four in number. Of these there are available in the Bureau of Science 137, 167, 193, 1223, 5087, and 8932, determined by Murrill;¹¹⁷ 14376, determined by Bresadola and Sydow ¹¹⁸ and confirmed by Graff; and 18341, determined by Sydow. Besides these published numbers there are also five collections [35833, 35870, 36007, 36121, and 36130 (Plate 16, fig. 3)] determined by Lloyd, one by Bresadola (9100), one by Graff (20389), and *Fungi Exotici Exsiccati* 308 of Sydow. Of these, 193 (*applanatum* for Lloyd), 14376 (Plates 17, fig. 24; Plate 35, fig. 1), and 18341 are typical *tornatum* of the Philippines; 8932 is a typical young specimen of variety *philippinense* such as Patouillard called *leucophaeum*; 20389 is a large-spored form of *tornatum*, which we segregate as forma *macrospora*; Sydow 308 is a compressed ungulate variety of *applanatum* with very thin context and smooth spores, which will be segregated as soon as the type of *annulare* can be examined. The others are all referable to the *Ganoderma mastoporum* assemblage. It should be noted here that among the missing specimens of *tornatum* there are 16025, which Graff ¹¹⁹ published as "*Ganoderma tornatum* var. *subtornatum* (Murr.) Graff comb. nov.;" and 13748, determined by Bresadola, which according to Lloyd ¹²⁰ is now at Kew and is the type of his *Fomes pseudo-australis*.

There are a number of other published species that belong in the *applanatum* group but upon which we can offer nothing

¹¹⁶ Mycologia 15 (1923) 100.

¹¹⁷ Bull. Torr. Bot. Club 35 (1908) 409.

¹¹⁸ Philip. Journ. Sci. § C 9 (1914) 347.

¹¹⁹ Bull. Torr. Bot. Club 48 (1921) 290.

¹²⁰ Myc. Notes 71 (1924) 1243.

constructive concerning the identity. A list of these with comments taken from the literature may be of some value in rounding out the paper.

POLYPORUS ADSPERSUS Shulz.

Placed by Patouillard ¹²¹ and Bourdot and Galzin as a synonym of *G. australe* (Fr.); by Bresadola as *australe* var. *europaea* Bres. (fide Bourd. and Galz.).

FOMES CHILENSIS Fr. [Nov. Symb. Myc. 63 (Sacc. Syll. 6: 176).]

Given by Bresadola ¹²² as a synonym of *australe* (Fr.), Lloyd ¹²³ says: "The type at Upsala, all that is known to me, is a thin subresupinate *Ganoderma*, about the same as usually called *australis*."

POLYPORUS DRYADEUS (Rostk XXVII, t. 9).

Cooke ¹²⁴ refers this to *applanatum*. Nicolas ¹²⁵ gives the same reference for the fungus in Sturm Pilze, VII, Heft 27, p. 17, t. 9, 1841-53.

POLYPORUS DUBIUS Jungh. (Herb. Leiden).

Both L  veill   and Cooke ¹²⁶ refer this to *australe* Fr.

BOLETUS FOMENTARIUS var. APPLANATUS PERS. [Syn. (1801) 536].

Bourdot and Galzin ¹²⁷ give this as a synonym of *applanatum*. Lloyd, ¹²⁸ speaking of the specimen in Persoon's herbarium at Leiden (Box 393), says there is a good specimen labelled by Persoon and it is *applanatus*.

POLYPORUS GALEGENSIS Mont. [Ann. Sci. Nat. II 16 (1841) 274-275].

Bresadola ¹²⁹ transfers this to *Ganoderma* and maintains it as a species. In discussing the type collection of *nigro-laccatus* Cke. he refers one of the two specimens to *galegense*.¹³⁰ Lloyd ¹³¹ lists it as a valid species with the comment, "very similar to *Fomes applanatus* as to pores, context and spores, but has a

¹²¹ Pat., in Bull. Soc. Myc. Fr. 5 (1889) 71; Bourd. & Galz., in Hym. France, (1928) 612.

¹²² Ann. Myc. 14 (1916) 223.

¹²³ Syn. Genus Fomes (1915) 279.

¹²⁴ Grevillea 15 (1886) 54.

¹²⁵ Bull. Soc. Myc. Fr. 42 (1925) 190.

¹²⁶ L  veill  , in Ann. Sci. Nat. III Bot. 2 (1844) 189; Cooke, in Grevillea 15 (1886) 54.

¹²⁷ Hym. France (1928) 611.

¹²⁸ Myc. Notes 35 (1910) 469.

¹²⁹ Ann. Myc. 14 (1916) 236.

¹³⁰ Hedwigia 53 (1912) 54.

¹³¹ Syn. Genus Fomes (1915) 265.

hard, thick, smooth, black (cracked) crust. The specimen on which the species is based is in a cupboard at Paris. We have noted other specimens of *Fomes applanatus*, determined as being *Fomes galegensis*, but none with the same crust feature of the type at Paris. We hardly think it possible to maintain it even as a form."

FOMES GELSICOLA Berl. [Malpighia (1889) 371; Sacc. Syll. 9: 180].

Bresadola¹³² refers this to *australis* Fr. Lloyd¹³³ remarks, "No specimen known to me, but from figures, description, and spores, it is based on a half-ungulate specimen of *Fomes applanatus*."

POLYPORUS LACCATUS Kalchbr. [Österr. Bot. Zeitschr. 35 (1885) 81-82].

This is a European species recognized as valid by modern students¹³⁴ of the group, said to be the same as *G. pfeifferi* Bres. and *Fomes advena* Quél. Rea¹³⁵ gives it as a variety of *applanatum*. Lloyd's illustration resembles the form of *applanatum* var. *philippinense* which Patouillard called *leucophaeum* in Philippine collections.

POLYPORUS LINGUA Lév. (apud Zollinger No. 360, non. Nees).

Patouillard¹³⁶ places this in *G. testaceum* (Lév.), while Bresadola¹³⁷ refers another of Zollinger's specimens (*Pl. Jav. 350y*) to his new variety *pulchella* of *Ganoderma gibbosum* (Bl. and Nees) Pat.

POLYPORUS LINHARTII Kalchbr.

Patouillard refers¹³⁸ this species to *G. australe* (Fr.).

GANODERMA LIONETII Rolland [Bull. Soc. Myc. Fr. 17 (1901) 180-181, pl. 8].

Murrill reports this in the North American Flora 9, part 2, page 115, from Nicaragua and Panama. A section of a small pileus in the senior author's herbarium from the former place determined by Murrill does not show the radiate wrinkling of the original illustration. It must be considered a doubtful determination. Lloyd¹³⁹ states, "Pileus covered with agglutinate wrin-

¹³² Lloyd, Myc. Notes 3 (1899) 23.

¹³³ Syn. Gen. Fomes (1915) 280.

¹³⁴ Lloyd, Syn. Gen. Fomes (1915) 266, fig. 603; Bourd. and Galz., Hym. France (1928) 612.

¹³⁵ Brit. Basidiom. (1922) 597.

¹³⁶ Leaf. Philip. Bot. 6 (1914) 2250.

¹³⁷ Ann. Myc. 10 (1912) 501.

¹³⁸ Bull. Soc. Myc. Fr. 5 (1889) 71.

¹³⁹ Syn. Apus Polyporus (1915) 371.

kles. No specimens seen, but species evidently based on the surface characters as shown on Bull. Soc. Myc. 1901, plate 8. It was from Mexico." The last statement is an error; it was originally described from the Isthmus of Panama.

BOLETUS LIPSIENSIS Batsch. (Elench. Fung. Contin. Prima, 183-186, pl. 25, fig. 130, *a*, *b*, 1786).

Atkinson¹⁴⁰ uses this as the earliest specific name for *applanatum*.

FOMES LONGOPORUS Lloyd [Myc. Notes 62 (1920) 940].

This species was named from Portuguese West Africa, but not adequately described or figured. The large pores are the only diagnostic character given.

POLYPORUS MERISMOIDES Corda [*in* Sturm Pilze III (1837) 139, t. 63].

Placed by Cooke¹⁴¹ and Nicolas¹⁴² as a synonym of *applanatum*. Saccardo (Syll. 6: 177) includes it as a "forma monstrosa" of *applanatum*.

POLYPORUS NIGRICANS Jungh.

Lloyd¹⁴³ says of this, "—Fomes australis teste Fries."

POLYPORUS OERSTEDII Fr. [Nov. Symb. (1851) 63].

Murrill¹⁴⁴ places this as a synonym of *tornatum*. Bresadola, Lloyd, and Saccardo consider it a valid species.¹⁴⁵

POLYPORUS PICEUS Ces. [Mycetum in itinere Borneensi lectorum, p. 5, *in* Atti. Reale Accad. Sci. Fis. e Math. Napoli 8: (1879)].

Lloyd¹⁴⁶ says of this, "No type known by me, but probably the same as Fomes pseudo-australis or Fomes subtornatus." The description suggests *mastoporum*.

FOMES POLYZONUS Lloyd [Syn. Gen. Fomes (1915) 269-270].

Originally collected by C. B. Ussher in Java.

¹⁴⁰ Ann. Myc. 6 (1908) 189.

¹⁴¹ Grevillea 15 (1886) 57.

¹⁴² Bull. Soc. Myc. Fr. 42 (1925) 190.

¹⁴³ Syn. Genus Fomes (1915) 283.

¹⁴⁴ N. A. Flora, Part 2, 9 (1908) 115.

¹⁴⁵ Bres., *in* Ann. Myc. 14 (1916) 239; Lloyd, *in* Syn. Apus Polyp. (1915) 370, fig. 705; Sacc. *in* Syll. Fung. 6: 178.

¹⁴⁶ Syn. Gen. Fomes (1915) 284.

BOLETUS RUBIGINOSUS Schrad. [Spic. Fl. Germ. (1794) 168].

Fries and Saccardo place this as a synonym of *Polyporus resinosus*.¹⁴⁷ Quélet¹⁴⁸ reported it for France, but Bourdot and Galzin¹⁴⁹ consider his fungus the same as *applanatum*.

Lloyd¹⁵⁰ remarks, "Europe, Schrader. This old vague record has been variously interpreted. Fries (late date) as a synonym for *Polyporus fuscus* of this pamphlet. Fries (at an early date) as *Polyporus fissilis* of this pamphlet. Fries specimen at Kew is *Polyporus cuticularis*. Bresadola Fungus Kmet. as *Fomes applanatus*, which is probably correct. The 'farina rubiginosa' of the pileus is no doubt the spore deposit that often mysteriously covers the top of the pileus of *Fomes applanatus*."

POLYPORUS SCANSILIS Berk. [Journ. Linn. Soc. Bot. 16 (1877) 53].

Described from a specimen (279) collected by the Challenger Expedition in Juan Fernandez. Lloyd¹⁵¹ says, "Based on a diseased condition of *Fomes australis* when the context has turned white. These conditions are not rare even in European and American forms of *Fomes applanatus*. I do not know what causes it, but judge it is a disease of some kind." Bresadola¹⁵² calls it *Ganoderma australe* (Fr.) forma *albinea*.

FOMES STEVENII Lév. [in Demidoff, Voyage dans la Russie méridionale et la Crimée, par la Hongrie, la Valachie et la Moldavie 2 (1842) 91, pl. 2].

Bresadola¹⁵³ states, "unknown, probably vegetus." Lloyd¹⁵⁴ says, "Specimen is not preserved in any museum I have visited. I have been told that it is in Italy. From the figure and description I judge it is *Fomes leucophaeus*."

FOMES VEGETUS Fr. [Epicrisis (1836-38) 464].

Although carried in Saccardo (Syll. 6: 179) as a valid species it is now quite universally considered a form of *applanatum*

¹⁴⁷ Fries, Hym. Eur., ed. 2 (1874) 554; Sacc. Syll. 6: 137.

¹⁴⁸ Assoc. Franç pour l'avanc. Sci., 20th sess. 2 (1891) 469.

¹⁴⁹ Hym. France (1928) 611.

¹⁵⁰ Syn. Apus Polyporus (1915) 385; also see Syn. Genus Fomes (1915) 284-285.

¹⁵¹ Syn. Genus Fomes (1915) 285.

¹⁵² Ann. Myc. 14 (1916) 227.

¹⁵³ In Lloyd, Myc. Notes 3 (1899) 22.

¹⁵⁴ Syn. Gen. Fomes (1915) 285.

or *australe* with cushions of sterile tissue between the layers of pores.¹⁵⁵

GANODERMA APPLANATUM (Pers.) Pat.

TEMPERATE-ZONE FORMS

UNITED STATES AND CANADA

Only seventeen specimens from the United States were available for examination (Plate 1, figs. 1 to 13). The senior author has collected it there frequently, however, in various parts of the country, and it is believed that the specimens studied are quite representative. On large logs or trunks it may reach a width of two feet or more. It is usually applanate, rarely unguulate, and usually grows singly, although many sporophores may occur scattered in close proximity over the logs. Occasionally it becomes loosely imbricate. While frequently strictly sessile and semicircular in outline there are also many forms that are contracted to a lateral stipelike base. Many of the sessile plants have a broad basal attachment, which in turn produces a strongly concave lower surface. Specimens growing in the dark or under much-reduced illumination frequently assume long digitate forms (Plate 1, fig. 12), while others are sufficiently regular (Plate 1, fig. 11) for easy determination.

The upper surface varies from almost plane to strongly convex, and is sulcate in all the specimens studied, becoming somewhat tuberculose or radially furrowed at times. The color is frequently dirty whitish, pale smoke gray to somewhat silvery, or near light buff (R), these light-colored specimens frequently having narrow concentric light brown zones; older or poisoned specimens are usually darker. The following additional colors of Ridgway have been noted: Clay color, Sayal brown, grayish olive or paler, near snuff brown, Verona brown, between army brown and Natal brown, and Saccardo's umber. It will be noted that five of these seven colors are on Plate 29 of Ridgway's Color Standards. Color zonation is present in nearly all to some degree.

The margin is subacute to blunt, and is often pale. The context varies from corky to woody, usually with distinct concentric zones, and is sometimes much thickened at the attachment.

¹⁵⁵ See Bourdot and Galzin., *Hym. France* (1928) 612; Hennings, *in Engl. Bot. Jahrb.* 14 (1891) 342; Lloyd, *Letter* 24 (1908) 2; *Letter* 44 (1913) 4; *Syn. Gen. Fomes* (1915) 286; Patouillard, *in Bull. Soc. Myc. Fr.* 5 (1889) 71; van der Bijl, *in So. Afr. Journ. Sci.* 18 (1922) 279.

It ranges for mature specimens between 1.5 and 6 centimeters thick, the fibers often radiating, particularly at the base. Narrow, harder radial streaks or interrupted lines are invariably present. These are most conspicuous at or near the attachment, where they usually radiate abundantly and thereby harden the tissue. They usually continue toward the margin in varying numbers and frequently almost attain it. They are black in most specimens but may occasionally be dark brown. The typical color of the context is near russet (R) but cinnamon brown (R), Sayal brown (R), Verona brown, (R), Mars brown (R), and snuff brown (R) were noted, two or more of these often being represented in the same specimen, sometimes as concentric bands, sometimes as color variations between the upper and lower areas. Where variations exist the area next to the pores is the darker. It will be noted that the colors mentioned above are closely related, largely a matter of minor shades. The greatest difference was in a specimen collected by J. R. Weir from *Abies grandis*, a very unusual host, in Idaho. The upper portion of the context was pinkish buff (R), the lower portion snuff brown (R). This was a young specimen, Saccardo's umber on the upper surface, and was quite aberrant, although unquestionably referable here.

A distinct crust (Plate 25, fig. 1) is present in all instances. This is not over 0.25 millimeter thick and is for the most part black in section, occasionally dark brown. In many cases it can easily be indented by the finger nail.

In fresh growing specimens the lower surface is white to whitish but on drying it becomes pallid to sordid, and on bruising becomes brown by exposure of the brown dissepiments of the tubes. This character makes it suitable for amateur sketching (Plate 1, fig. 7). The pore surface in herbarium specimens, therefore, shows a wide range of color, depending on the age and the amount of care used in handling the fresh material. Poisoning with corrosive sublimate dissolved in alcohol also darkens the surface, even of dried material. The color of the lower surface in the material at hand, most of which is unpoisoned, varies from near light ochraceous buff, sometimes tinged with olivaceous, to rather dark brown. The Ridgway colors noted are deep olive buff, near wood brown, buffy brown, near Saccardo's umber, Natal brown, and dusky brown; army brown to Verona brown where distinctly bruised.

The sporophores have one to four layers of pores (Plate 25, fig. 1), varying in maximum length from about 1 to 1.5 centimeters for well-developed specimens. Their general color in longisection ranges within the following limits (Ridgway): Light brownish drab, brownish drab, near cinnamon drab, near wood brown, near snuff brown, and near Verona brown. The presence of white mycelium within many of them lightens the shade somewhat in section, the dissepiments, as a rule, being the color of the lower layer of context from which they arise. The orifices (Plate 22, figs. 1, 2, and 5) are circular to angular, the dissepiments thin to thick, but more usually thin to medium, with the edges often somewhat eroded. They vary in size up to 100 per cent (ratio 1 : 2). In number per millimeter the averages of five to six measurements per specimen range from 4.5 to 6.7, the grand average for ninety-two measurements on sixteen specimens being 5.3.

Six representative specimens were examined (ten measurements per specimen) for ratio of pore-wall thickness to diameter of pore. The walls varied from 42 to 417 μ and the pores from 139 to 486 μ the average ratios ¹⁵⁶ for the five specimens being 1 : 0.73, 1 : 1.60, 1 : 2.10, 1 : 2.54, 1 : 2.75, and 1 : 2.77, respectively.

A form of *Ganoderma applanatum* with a large part of the context and the older pore layers bleached to light buff (R) or pinkish buff (R) occurs in the western United States (Plate 1, fig. 1). The writer has frequently found it on *Tsuga heterophylla* and occasionally on oak in the Pacific Coast region. In as much as the form is frequently associated with typical specimens it cannot be considered more than a minor variation, although it is of striking appearance in section. It varies from applanate to compressed-ungulate; one small specimen is unguulate and was attached at the vertex. The upper surface is fawn color (R) to Verona brown (R), often blackish where rubbed. The context is comparatively thin, with radiating fibers, corky, whitish to light buff (R) and may be heavily streaked with Sayal brown (R) to Saccardo's umber (R), obscurely zoned, and with a few dark brown harder streaks. The crust (Plate 29, fig. 1) is thin, up to $\frac{2}{3}$ millimeter, and frequently cracked. The pores are indistinctly layered, occupying from three-fourths to seven-eighths of the total thickness. All

¹⁵⁶ Ten measurements each of the walls and the diameter of the pores were made. These were added and the total of the wall thickness was divided into the total of the diameter to give the average ratio.

except the last layer (Plate 30, fig. 1; Plate 31, fig. 1), and perhaps a portion of the next to the last, are bleached to light buff (R) or pinkish buff (R) with occasional scattered vertical streaks of the same color as the unchanged pores, which are near to Verona brown (R) or snuff brown (R) in longitudinal section. The under surface is nearly concolorous with the pore section.

This same bleaching is also found in specimens of *applanatum* or its variants from the Philippines (Plate 5, figs. 13 and 14; Plate 28), and elsewhere, and the tendency for the context to be somewhat lighter just beneath the crust, even to becoming light buff, can frequently be noted. Lloyd, and Cleland and Cheel speak of this bleaching as being caused by a parasitic growth. I am of the opinion that it is an autodigestive process, since the hyphæ are much smaller in diameter and with thin walls (Plate 31, fig. 2) as if they had been subjected to gradual uniform fermentation.

Spores (Plate 32, figs. 1 to 3) in the United States material are brown in mass. At 500 to 600 magnification, after treatment with 7 per cent potassium hydroxide, the young ones vary from olive buff (R) to deep olive buff (R) while the older, more mature, ones are somewhat darker, ranging from deep olive buff to dark olive buff (R). The characteristic striæ in the hyaline epispore vary from fine to moderately coarse (oil immersion) and are distinct; usually they are rather fine. Those derived from a crushed mount of the pores average for one hundred fifty measurements (ten each from fifteen different collections) 5.41 by 8.15μ ; while forty measurements of spores from the upper surface of four collections gave an average of 6.35 by 9.15μ .

SPECIMENS EXAMINED

CANADA, Quebec, Lake Kenogami near St. Cyriac, on *Betula* sp., *C. J. Humphrey 10406* (H).¹⁵⁷

UNITED STATES, Florida, Miami, on living *Coccolobus* sp., *C. J. Humphrey 6981* (H.); Idaho, Clearwater, on *Abies grandis*,

¹⁵⁷ Abbreviations are given in parenthesis, following the number, to indicate the herbaria in which the specimens cited are deposited. Thus, (B) refers to the Baker herbarium, at Los Baños, Philippine Islands; (Bg) to the Buitenzorg herbarium; (B. S.) to the Bureau of Science, Manila; (H) to the Humphrey herbarium; and (S) to the Singapore herbarium. Since the largest part of the specimens are from the Bureau of Science herbarium this designation has been omitted wherever possible, although it was necessary to use it in referring to exsiccatae specimens, or Bureau of Science specimens deposited in duplicate in the Baker herbarium.

C. H. Shattuck (ex herb. *J. R. Weir*) (B.); Illinois, Cypress, on *Fraxinus nigra*, *C. J. Humphrey* 1369 (H.); Iowa, Woodbine, on *Pyrus malus*, *C. J. Humphrey* and *C. W. Edgerton* 2344 (H); Maine, Bowdoinham, *C. G. Penney*, Bu. of Plant Industry pathological and mycological collections 962 (B. S.); Minnesota, Princeton, on living *Quercus alba*, *C. J. Humphrey* 934 (H.); New York, Syracuse, Catskill Mountains, on *Acer saccharum*, *L. H. Pennington*, New York State College of Agriculture 13 (B.); Oregon, Eugene, on *Quercus lobata*, *C. J. Humphrey* 6083 (H); Pennsylvania, Sayre, *W. C. Barbour*, *Kryptogamae exsiccatae* [Vienna] 1143 (B. S.); Washington, Hoquiam, on *Tsuga heterophylla*, *C. J. Humphrey* 2348 (H), 6365 (H); Wisconsin, Madison, *M. C. Jensen* "B" (B. S.), on living *Pyrus malus*, *C. J. Humphrey* 881 (H), on living *Prunus serotina*, *C. J. Humphrey* 882 (H), on *Salix* sp., *M. C. Jensen* "C" (B. S.), Menasha, on *Acer* sp., *M. C. Jensen* "A" (B. S.).

EUROPE

Four specimens only were available from Europe; namely, two from England, one from Austria, and one from Russia. All were represented by slices. One of the English specimens was ungulate, with at least seven layers of pores which were nearly continuous (Plate 1, fig. 14). Context hard corky, russet, with small interrupted bleached streaks; pores between Verona brown (R) and snuff brown (R); the other specimen was small, applanate, of harder consistence throughout, and with somewhat darker context. This latter can frequently be closely matched with Japanese material, and occasionally with Brazilian. Both have circular to subangular pores, with medium to thick entire dissepiments (Plate 22, figs. 3 and 4; Plate 25, fig. 7). In one they average 4.2 to a millimeter, in the other 4.9.

The Russian and Austrian specimens were of light weight, applanate, and quite alike in color and consistency. Context corky and very light colored for the species, near clay color (R) above and warm sepia (R) next to the pores in the Austrian specimen; predominantly the latter color throughout the Russian. Upper surface tinged with olivaceous, with a thin soft crust. Pores near wood brown (R) in section; the mouths circular to angular, the dissepiments thin to medium, entire to somewhat eroded, averaging 4.7 to the millimeter in the Austrian specimen. Both plants were of the "*vegetus*" type with dis-

tinct layers of sterile tissue between the pore layers. They offer a distinct variation from the English material at hand.

The English and Austrian specimens were examined for ratio of pore wall thickness to diameter of opening. The walls in the former varied from 56 to 306 μ and the pores from 167 to 459 μ , with average ratios of 1 : 0.98, and 1 : 2.73, respectively. The Austrian specimen ranged from 28 to 167 μ for the walls and 208 to 445 μ for the pores, with an average ratio of 1 : 3.79.

The spores of the European material offer little variation from the American. Those from the English specimens (Plate 32, figs. 4 and 5) averaged 6.1 by 9.6 μ ; from the Austrian 5.2 by 7.8 μ ; and from the Russian 6.2 by 9.2 μ . The above measurements were all made on spores crushed from the pore tissue.

SPECIMENS EXAMINED

AUSTRIA, Sonntagberg Mountains, near Rosenau, *P. P. Stras-ser, Kryptogamae exsiccatae* [Vienna] 940 (B. S.).

ENGLAND, Epping Forest (*ex Herb. Hort. Bot. Reg. Kew.*) (B. S.); Kew, A. D. Cotton (*ex Herb. Hort. Bot. Reg. Kew.*) (B. S.).

RUSSIA, Province Černigov, district Ostjor, prope Černyn, on *Populus tremula*, G. Newodowski (B.).

SOUTH AMERICA: URUGUAY

One typical specimen from Montevideo was examined (Plate 2, fig. 1). This was thick, two-layered, with a bay (R), firm corky context 2 centimeters thick and a cushion of sterile hyphæ between the layers. Upper surface weathered, approaching grayish olive (R), rimose, sulcate. First layer of pores 2 centimeters long, typical in color, with rather thick-walled dissepiments. Spores typical in color, with coarse distinct striæ, rather large, but falling well within the range for the species, averaging 6.5 by 10.7 μ for ten measurements from a crushed mount.

SPECIMEN EXAMINED

Montevideo, Carnevale, *Mus. Botan. Montevicens*, 782.

JAPAN

Nine specimens (Plate 1, figs. 15 and 16; Plate 2, figs. 2, 3, 4, 7, to 11) from southern and northern Japan were examined. These were all comparatively small, up to 11 centimeters long, about 12 centimeters wide, and 3 centimeters thick, none being of the large broadly applanate form so common in the United States. Most of them were strictly sessile, but one was contracted to a stipelike base. Upper surface usually convex,

sulcate, often rather irregular, varying in color from dull silvery gray through avellaneous (R) and fawn color (R) to brown; black in occasional old specimens. One specimen was near smoke gray (R) concentrically banded with benzo brown (R) (Plate 2, figs. 7 and 8). Another very young specimen was Natal brown (R) at the margin, then wood brown (R), and finally near cartridge buff (R) behind.

The lower surface varied from near pinkish buff (R) through pale brownish with olivaceous cast to wood brown (R), and finally to buffy brown (R), or occasionally olive-brown (R), becoming benzo brown (R) to dark vinaceous drab (R) on bruising.

Context corky to woody, usually varying from cinnamon brown (R) and russet (R) to chocolate (R), the colors often being mixed in the same sporophore. One specimen had a narrow Verona brown (R) layer next the pores, shading out to light buff beneath the crust. Obscure to distinct concentric zones were present in all, the fibers radiating from the base and becoming more parallel toward the margin. Hard, shining black, interrupted streaks (Plate 25, fig. 5) were numerous at the base of the sporophores, and frequently extended in lesser number nearly to the margin. Where abundant the tissue was quite hard.

A hard black crust varying from 0.25 to 1 millimeter in thickness was always present, the thickness determining the ease with which the crust could be indented. It was frequently cracked in dried specimens and usually extended entirely around the blunt margin; sometimes, however, in specimens with an actively growing margin it was absent over that portion.

In longisection the pores varied from near wood brown (R) to near chestnut brown (R) or Mars brown (R). Most of the specimens showed only one pore layer and since this was frequently not fully developed the pores were only 5 to 7 millimeters long. In those plants collected previous to the month of May the pores apparently represented the previous year's growth and varied from 13 to 20 millimeters in length. In shape (Plate 22, figs. 7 and 8) they varied from circular to angular, more commonly subangular. In some specimens they were almost uniform in size; in others the ratio ran as high as 1 : 2, the average for nine specimens examined being 1 : 1.4. The average number per millimeter was 4.8, based on sixty measurements on nine specimens, the averages for the different specimens ranging between 4.0 and 5.7. The dissepiments va-

ried from thin to thick, the more usual condition for mature specimens being thin to medium, the thinner ones being frequently eroded.

Three specimens were examined for the ratio of pore-wall thickness to diameter of opening. The walls varied from 70 to 417 μ and the pores from 111 to 417 μ , the average ratios being 1 : 1.08, 1 : 1.44, and 1 : 3.36, respectively.

The spores (Plate 32, figs. 6, 7 and 8) had the same variation in color as the American material, but the striae tended to be coarser. All gradations from fine to coarse were present, however. Those derived from the crushed pores averaged for eighty measurements on eight collections 5.45 by 8.35 μ . Ten measurements of spores from the upper surface of one specimen averaged 6.3 x 9.5 μ . These measurements are in close agreement with those from American specimens and are in sufficiently close accord with those from European material.

Among the Japanese specimens there were two (11537, 12586) which had the same type of smooth nonstriate spores as later described by the senior author for *Ganoderma applanatum* var. *laevisporum*. While one of these (11537) was sufficiently distinct from *applanatum* to constitute a good variety (Plate 1, figs. 15 and 16; Plate 32, fig. 8) the other was indistinguishable, in all characters except spores, from another specimen (11618) which had typical striate *applanatum* spores. Therefore it seems best to leave all in the base species until enough material is available to make the proper varietal segregation. At present the senior author would consider the smooth-spored forms as transitional between *applanatum* and its more southern high altitude variety *laevisporum*.

SPECIMENS EXAMINED

Tokyo, Meguro, Forest Experiment Station, on *Fraxinus* sp., K. Kitajima (1), on *Quercus serrata*, R. Fukazu, comm. K. Kitajima (21) 12502 (H); Kyoto, T. Hemmi et al. (25); Yamato Province, Kamikitayama-Mura, Yoshino-gun, H. Migo (20) 12587 (H), Kawakami-Mura, Yoshino-gun, H. Migo (19) 12586 (H); Hyuga Province, Aoshima, H. Migo (24) 12589 (H); Osumi Province, Koyama, H. Migo (25) 12583 (H); Nikko, Lake Chuzenji, C. J. Humphrey, K. Kitajima and I. Miura, 11537 (H); Tomakomai, C. J. Humphrey and I. Miura, 11617 (H), 11618 (H); on *Acer palmatum*, C. J. Humphrey and I. Miura, 11621 (H).

CHINA

Three collections were available for study, one of which was rather abortive. The other two were applanate, sulcate to rugose-sulcate, approaching smoke gray to grayish olive or wood brown above (Plate 2, figs. 5 and 6). Context corky to very firm, up to 2 centimeters thick, concentrically zoned, near to russet (R), but varying either somewhat darker or lighter. Under surface strongly tinged with olive buff. Pores (Plate 22, fig. 9) with a maximum length of 11 millimeters, angular to subangular, averaging 4.7 to a millimeter; ratio of variation 1 : 2. Dissepiments thin to medium, entire to somewhat eroded. The plants approach sufficiently close to American material and in turn resemble certain of the Philippine collections.

Spores of the same color as in American and European specimens, the striæ being rather coarse, the average of thirty measurements from crushed mounts of three collections being 5.5 by 8.3 μ .

SPECIMENS EXAMINED

Kwangsi, Tang Uen, *O. A. Reinking*, 4593 (B); Kwangtung, Paak Shan, on *Nephelium lichee*, *O. A. Reinking*, 4684 (B); Hongkong, *C. J. Humphrey*, 11623 (H).

FORMOSA

Five good specimens from Formosa were examined (Plate 2, figs. 12 and 13). These varied from a small subungulate form to applanate, and from sessile or contracted at the base to short laterally stipitate, convex, sulcate, and occasionally somewhat tuberculose above; largest specimen 15 centimeters long, 5 centimeters thick at base. Upper surface varying from light buff tinged with avellaneous (R) (in a very young specimen) through wood brown (R) to drab (R), and finally hair brown (R) in old specimens.

Context corky to woody, from 1 centimeter to 3 centimeters thick, russet (R) to chocolate (R), usually concentrically zoned with bands of somewhat lighter color; the usual hard black streaks and distinct black crust present in all specimens.

Lower surface of the youngest specimen (1.75 inches long) cartridge buff (R) at the sterile margin and light buff (R) over the remaining area. Older specimens were drab gray (R) and light drab (R) to mummy brown (R), with the exception of one specimen that was stained with olive buff over part of the surface.

All specimens had a single pore layer which varied from 4 millimeters to 2 centimeters thick, the dissepiments being concolorous with the lower layers of the context, the tubes often white within; general color varying from a pale benzo brown to warm sepia (R).

The pores (Plate 22, fig. 10) varied in shape from circular to angular, more commonly subangular to angular, with medium to thin dissepiments, which were entire or somewhat eroded. The size varied about 50 per cent. The number per millimeter varied from 4.4 to 5.2, the average for twenty-four measurements on four specimens being 4.8.

Three representative specimens were examined for ratio of pore-wall thickness to diameter of opening. In forty measurements the walls varied from 56 to 250 μ and the openings from 167 to 486 μ , the average ratios for the three being 1:1.86, 1:2.26, and 1:2.42, respectively.

The spores (Plate 32, fig. 9) were of typical color, with rather coarse striæ. Those from crushed mounts averaged for thirty measurements on three specimens 6.46 by 9.56 μ , while twenty from the upper surface of two other specimens averaged 6.30 by 9.35 μ . They are thus practically the same size as those from American, European, and Japanese specimens. Similarities in all other respects are likewise quite close.

SPECIMENS EXAMINED

Mahebo, *K. Sawada* (6) (H); Taihoku, *K. Sawada* (66, 78) (H), on *Nephelium longana*, *K. Sawada* (50) (H); Toyohara, on living *Alnus formosana*, *K. Sawada* (68) (H).

AUSTRALIA

Fourteen specimens were examined, all from the temperate regions (Plate 3, figs. 1 to 11; Plate 25, fig. 2). They varied widely in shape and thickness of context but had the general appearance of the species. Several were subungulate, others comparatively thin applanate. Upper surface sulcate, sometimes very uneven, rather rimose in age. One young specimen was near Sayal brown (R) above, but they were for the most part pale brown to Verona brown (R) or darker, in some cases tending toward blackish. Two of them were grayish olive (R) to dark grayish olive (R), at least over part of the surface.

The context was corky, from 4 millimeters to 3.5 centimeters thick, usually around auburn (R) to bay (R), occasionally russet; with the upper layer cinnamon brown (R) in one specimen. The hard black streaks in the context, usually so conspicuous

in *applanatum* collections were lacking or inconspicuous in many of the Australian. They were replaced to a certain degree in some of the specimens by softer fawn-colored, more or less interrupted, streaks (Plate 3, figs. 5 and 6), such as one frequently finds in variety *philippinense*.

The pore surface was usually pallid to medium brown. The pores (Plate 22, fig. 6; Plate 25, fig. 2) varied from circular to angular, most of them being subangular to angular, differing in size in a single specimen about 50 per cent. They ranged between 3.5 and 5.5 to a millimeter, with averages based on six measurements on each of six specimens from 4.1 to 5.0, the average of the whole series being 4.8.

Six specimens were examined for ratio of thickness of dissepiments to size of pore orifice. The walls varied from 56 to 278 μ and the pores from 83 to 278 μ , the respective average ratios for the six being 1 : 0.70, 1 : 1.07, 1 : 1.33, 1 : 1.46, 1 : 1.47, and 1 : 2.01. It is thus seen that the pores average somewhat larger than in the forms from the United States. Dissepiments thin to thick, more usually medium to thick, the thin ones being somewhat eroded at times.

The spores (Plate 32, figs. 10 to 12; Plate 33, figs. 1 and 2) varied from olive buff to dark olive buff, with rather coarse distinct striæ. They averaged rather large for the species, those derived from crushed mounts being 6.69 by 10.76 μ , based on eighty measurements, ten spores from each of eight specimens. Those from the upper surface were slightly larger and averaged 6.98 by 11.07 μ (one hundred four measurements from ten specimens). In respect to size they are nearly as large as the spores of variety *brownii* Murr. from the Pacific coast of the United States. In other respects some of the Australian plants (Plate 3, figs. 1 and 2) also approach the American variety, but there appear to be sufficient minor differences to warrant retaining them in the base species rather than to increase the variability of the variety.

Certain of the specimens were thin and applanate, with the thin context of variety *tornatum*, but otherwise they are better referable to *applanatum*, particularly in the size and character of the spores. Only one specimen had typical *tornatum* spores; on other characters, however, it would normally be placed in thin *applanatum*. There is so much intergrading in the *applanatum* assemblage that some fairly constant character, such as the spores, must be selected for varietal segregation and hence this specimen has been placed under the variety indicated.

SPECIMENS EXAMINED

Flinders Island, Bass Straits, *J. B. Cleland* (9); New South Wales, *J. B. Cleland* (10, 27), Lisarow, *J. B. Cleland* (8), Mount Wilson, *J. B. Cleland* (7), National Park, *J. B. Cleland* (3), Sydney, Mosman, on living *Angophora lanceolata*, *J. B. Cleland* (2), Wingham, *J. B. Cleland*, (5); Queensland, Bunya Mountains, *J. B. Cleland* (11); South Australia, Adelaide, Burnside, on old pepper tree, *Schinus mollis*, *J. B. Cleland* (1), Encounter Bay, *J. B. Cleland* (13); Tasmania, National Park, *J. B. Cleland* (14); Victoria, on decaying log, Upper Fern-tree Gully, *E. Cheel* (*Nat. Herb. N. S. Wales*, 5990) (B); West Australia, Perth, Zoölogical Gardens, *W. N. Cheesman* (*ex Herb. Hort. Bot. Reg. Kew.*) (B).

NEW ZEALAND

A portion of a small subungulate specimen from Dr. J. B. Cleland was examined. This was in close agreement with certain of the Australian specimens. Upper surface dark, tinged with hair brown, sulcate, rimose, with a black crust 3 millimeters thick. Context somewhat darker than bay, corky. Lower surface light brown, discolored, with circular to subangular pores 4.2 to the millimeter. Dissepiments thick, entire. Spores of typical color, with moderately coarse distinct striæ, 6.7 by 10.4 μ (crushed mount), 6.9 by 10.7 μ (from upper surface).

SPECIMEN EXAMINED

Wellington, *J. B. Cleland* (4).

TROPICAL FORMS

BRAZIL

Eight Brazilian specimens collected by Father Rick were examined (Plate 4, figs. 1 to 10), the description being drawn from the six referable to *applanatum*. These varied from moderate-sized ungulate or applanate forms to small substipitate ones, and in consistency from corky to hard and woody. Upper surface broadly to lightly sulcate (in steps in the ungulate specimen), usually convex and occasionally somewhat tuberculose; color varying from avellaneous (R) and wood brown (R) to cinnamon brown (R); one aberrant specimen of a general clay color (R) obscurely banded with Verona brown (R).

The context color varied within the usual limits, around russet (R), auburn (R), chestnut (R), and bay (R). Where comparatively thick it showed obscure to distinct concentric

zones. The forms with thin context approached variety *tor-natum* of the eastern Tropics in that respect but appeared more closely allied to *applanatum* in other characters and could not be specifically separated from other specimens with thick context from the same region. They were also very much like several of the specimens from Japan. Hard black streaks, abundant to occasional, were present in all specimens; also a hard black crust from 0.2 to 1 millimeter in thickness, the thinner being easily indented with the finger nail.

The lower surface was variable in color, with distinct olivaceous shades in three of the six specimens. The pore surface of the very young specimen sent out as *australe* by Theissen (254) approached light buff (R) with an olivaceous cast; others were near deep olive buff (R) discolored Natal brown (R), one having olive-ocher (R) at the margin of growth superimposed on the pores of a good-sized sporophore; still others were wood brown (R) to snuff brown (R).

The ungulate specimen had three indistinct pore layers corresponding with the "steps" of the upper surface; the pores were continuous, however, and not interrupted by a sterile layer. The remaining specimens showed but one layer. Their color in section was quite uniform, near dark vinaceous drab (R) or somewhat paler. The length varied from 4 millimeters to 2 centimeters.

In shape the pores (Plate 22, fig. 12) varied from circular to angular, more usually circular to subangular, with dissepiments medium to thick and entire, occasionally thin and slightly eroded. They varied in size about 50 per cent (ratio 1 : 1.5), and from 4.8 to 5.8 per millimeter, the average of thirty measurements on five specimens being 5.2 per millimeter.

Five representative specimens were examined for ratio of pore-wall thickness to diameter of opening. The walls varied from 70 to 375 μ and the openings from 111 to 306 μ , the average ratios being 1 : 0.80, 1 : 0.84, 1 : 0.93, 1 : 1.17, and 1 : 1.93, respectively.

The spores (Plate 33, figs. 3 and 4) were typical in color, deep olive buff (R) to dark olive buff (R) under high power, the young ones being somewhat paler. The striae varied from rather fine to coarse, usually moderately coarse, distinct. Those from the crushed mount averaged 6.08 by 9.72 μ for fifty measurements on five specimens, while eighty measurements from the upper surface of four specimens gave an average of 6.89 by 10.38 μ .

Two of the collections (Plate 4, figs. 1 to 3, 8 and 9) studied resemble *testaceum* Lév., which will be discussed in a forthcoming paper. They were all forwarded by Father Rick as *Ganoderma applanatum*, with the exception of Theissen's *exsiccata*, which was distributed as *Ganoderma australe* Fr.

The current views on Lévillé's species are presented on page 506.

SPECIMENS EXAMINED

Rio Grande do Sul, *J. Rick, herb. Humphrey 11055, 11057*; Nova Petropolis, *J. Rick, herb. Humphrey 10754, 11058*; Parecy, *J. Rick, herb. Humphrey 11054*; S. Leopoldo, *J. Rick, Theissen Decades fungorum brasiliensium 254*.

AFRICA: UGANDA

One specimen from Uganda, 12 centimeters wide, 8 centimeters long, was available. This was of the applanate form, of light weight, near snuff brown (R) above with obscure zones of slightly darker color, lightly sulcate, somewhat rugose, margin pale.

Context corky, near bay (R), 2 centimeters thick, with a few harder streaks intermediate between brown and fawn color, obscurely zoned.

Lower surface near buffy brown (R) tinged with olive buff (R) in places, particularly at the margin, avellaneous (R) where bruised. Pores (Plate 22, fig. 11) angular, 4 to 4.5 to a millimeter, averaging 4.2, quite variable in size. Dissepiments thin, slightly eroded.

Spores (Plate 33, fig. 5) typical, with moderately coarse striæ, 6.4 by 8.5 μ from the crushed mount, 6.1 by 8.9 μ from the upper surface.

SPECIMEN EXAMINED

Gunda Forest, Entebbe, *T. D. Maitland 377 (H)*.

CEYLON

One-half of a specimen (Plate 4, figs. 11 and 12) originally 22 centimeters wide, 12 centimeters long, was available through the courtesy of the Botanical Garden at Peradeniya. This was a typical, applanate, strongly sulcate form banded with cinnamon-drab (R) and lighter and darker shades, with a buff somewhat rounded margin.

Context corky, russet, concentrically zoned, with only traces of the harder black streaks, 5.5 centimeters thick at the gibbous base, thinning to 6 millimeters at mid-length.

Lower surface near buffy brown (R) except for paler areas, bruising to Verona brown (R). Pores up to 1.5 centimeters long, near snuff brown (R) in longisection, subangular to angular, rather regular in size, averaging 4.8 to the millimeter. Dissepiments medium, for the most part entire.

Spores near deep olive buff, with moderately coarse distinct striæ, averaging 6.3 by 9.6 μ from the crushed mount.

Another specimen (Plate 4, figs. 13 and 14) labelled "*Fomes annularis* Lloyd, stratose form of *Fomes applanatus* P." was also received from Peradeniya. This was an ungulate form 10 centimeters wide, 5 centimeters long, 4 centimeters thick, with a thin context of the same general color as the other specimen. Pores also of the same color in longisection, not stratified, with mouths somewhat larger, 4 to the millimeter. Spores olive buff to deep olive buff, with moderately rough distinct striæ, averaging 7.0 by 9.5 μ . We are inclined to leave this in *applanatum* as a minor form until more is known about *annulare*.

SPECIMENS EXAMINED

Herb. Peradeniya 4960, and unnumbered specimen labelled *Fomes annularis*.

DUTCH EAST INDIES

Among the Ganodermas loaned for study by the Buitenzorg Botanical Garden there were two comparatively young ones which are distinctly referable to *applanatum*. One of these (Plate 5, figs. 1 and 2), from Sumatra (2654), was determined by van Overeem as *Fomes oroflavus* Wilson, the other was unnamed and was entirely devoid of spores, although having a layer of short pores up to 5 millimeters long.

The fertile specimen from Sumatra was of the "vegetus" type, originally probably 18 to 20 centimeters wide but only 7 centimeters long, 4 centimeters thick behind, tapering to a thin blunt margin. Upper surface irregularly sulcate, quite uneven, somewhat rimose, near snuff brown (R) with a buffy margin, dark brown behind.

Context corky, near to russet, distinctly concentrically zoned, with two hard black streaks in the sterile tissue, which is up to 1 centimeter thick between the two pore layers.

Lower surface suffused with isabella color (R), chocolate (R) where bruised.

Pores 5 to 7 millimeters long, angular, averaging 4.2 to a millimeter, often larger by coalescence. Dissepiments thin, considerably eroded.

Spores atypical for the species, deep olive buff to dark olive buff, 6.1 by 8.3 μ , with coarse, short, very distinct striæ, like variety *tornatum*.

The specimen is quite like certain of the Chinese and Philippine collections which, likewise, are rather young and with atypical spores.

SPECIMENS EXAMINED

Borneo, W. Koetai, *F. H. Endert* (1675) 6216 (Bg); Sumatra, Fort de Kock, on dead trunk of *Ficus benjamina*, *Ed. Jacobson* (187) 2654 (Bg).

PHILIPPINE ISLANDS

Comparatively few of the Philippine collections are referable to the base species and these are rather of a miscellaneous lot coming usually from the higher altitudes. There are specimens which closely match certain of the irregular thick forms from the United States, while others closely match Chinese and Japanese material. The distinction between the base species and variety *philippinense*, which is very common in the Philippines and approaches the broadly applanate forms of *applanatum* more closely than does any other variety, is rather difficult at times as there is a very wide variation within the variety. Inasmuch as the spores may not be a safe criterion, those specimens with the black context streaks so typical of *applanatum* are placed there, while specimens having distinct softer fawn-colored ones are placed in the variety. In its typical form, however, the variety is very easy to segregate by means of other characters. One specimen from Australia (5990) referred in the present paper to *applanatum* bore a very close resemblance to a specimen from the Philippines referred to the variety, but had somewhat larger spores and black streaks mixed with fawn-colored ones in the context. Another specimen from Australia (*Cleland* 14) showed a similar tendency (Plate 3, figs. 5 and 6) and for the same reasons was referred to the base species.

The Philippine specimens of *applanatum* (Plate 5, figs. 3 to 16) vary in shape from thick irregular tuberculose forms to small subungulate or applanate ones. Upper surface sulcate to subsulcate, often quite uneven, varying in color from pale grayish (approaching smoke gray (R) to near neutral gray (R) or even darker), with the browns represented by wood brown (R), snuff brown (R), and Natal brown (R); bruising at times to chocolate (R).

Context corky to woody, comparatively thick for the length of the pores, usually 1 to 2 centimeters, russet to bay, usually concentrically zoned. One specimen with a bay context had the layer just beneath the crust and the upper portion of the pores bleached to whitish. Hard black streaks were present in all except one very young specimen. They were usually quite noticeable.

Lower surface pallid to near ochraceous buff (R) or medium shades of brown, occasionally dark brown.

Crust varying from thin, soft and easily indented with the finger nail, to hard and up to 1.5 millimeters thick.

Pores (Plate 22, fig. 13) circular to angular, usually sub-angular, ranging from 4.5 to 6.0 to a millimeter for seven representative specimens, the average for the 42 measurements being 5.2. Dissepiments thin to thick, entire to somewhat eroded.

Seven representative specimens were examined for ratio of pore wall thickness to diameter of opening. The walls varied from 14 to 167 μ and the pores from 70 to 208 μ , the average ratios being 1 : 1.16, 1 : 1.20, 1 : 1.88, 1 : 1.92, 1 : 1.96, 1 : 2.13, and 1 : 4.80, respectively.

Spores (Plate 33, figs. 6 to 8) deep olive buff to dark olive buff when apparently mature, near olive buff when young, with fine to coarse, usually distinct, striæ. Those from the crushed mount averaged 5.29 by 8.35 μ for one hundred twenty-two measurements on thirteen specimens, while those from the upper surface of two specimens, one of which had spores considerably larger than usual, averaged 6.4 by 10.2 μ .

Nearly all the specimens here referred to *applanatum* are comparatively young, often rather abortive. This influences the spore characters to such an extent that they were rarely typical of the species. Some of the collections had spores that could readily be referred to variety *tornatum*, and even in the same crushed mount the *tornatum* and *applanatum* types were mixed. It is believed that these aberrant forms are a transition between the species and its variety, but on account of the thick typical *applanatum* context they have been referred to the base species. The same intermediate type of spore was found in some of the Chinese and Japanese specimens, particularly in the younger ones. More high-altitude collections must be made in the Philippines before definite conclusions can be drawn as to the normal structure and appearance of fully mature sporophores.

SPECIMENS EXAMINED

LUZON, no locality given, *Father Sanchez* 16195, 45860, 45861, 50097; Benguet Province, Santo Tomas, *M. S. Clemens* 6315, *C. J. Humphrey* 50100, Pauai, *R. C. McGregor* 8734; Camarines Sur Province, Mount Isarog, *G. Edaño* 50099; Laguna Province, Mount Banahao, above Majayjay, *R. C. McGregor* 50102; Nueva Vizcaya Province, Bambang, *M. S. Clemens* 4391; Pampanga Province, Mount Arayat, *R. C. McGregor* 42071; Zambales Province, Castillejos, *M. S. Clemens* 3289. Palawan, Iwahig River, near Mount Mantaliñgahan, *Buenaventura Reyes* 50101; Panay, Antique Province, *R. C. McGregor* 32664, Capiz Province, Mount Salibongbong, *A. Martelino and G. Edaño* 50098.

GANODERMA APPLANATUM (Pers.) Pat. var. BROWNII Murr.

This species was described by Murrill¹⁵⁸ in 1915 from California, under the name *Elfvingia brownii*, where it grows on both living and dead *Umbellularia californica* and *Quercus agrifolia*. C. F. Baker collected it in 1901, near Palo Alto, California, and sent it to Peck, then New York State botanist, who determined it as *Fomes applanatus* Pers., under which name it was distributed in *Baker's Pacific Slope Fungi* 339. The senior author made two collections at Berkeley, California, on *Umbellularia* and *Quercus* in 1909 and referred them, likewise, to *Fomes applanatus*. In 1914, H. A. Lee collected the same thing at Berkeley; this specimen is deposited in the University of California herbarium, 1036. In 1915, the senior author found it again in abundance at Berkeley. In all, ten collections from California are at hand for study. In addition to the Californian material the senior author would also refer to this variety Bornmuller's *Plantae Exsiccati Canarienses*, 1900, 45 (Univ. Wisconsin herb.) distributed from Tenerife as *Polyporus australis* Fr.

The plant (Plate 6) is thick, ungulate to compressed-ungulate, sessile, broadly attached, often with the margin sulcate-truncate, or in young specimens blunt to rounded.

Upper surface slightly to distinctly sulcate, somewhat rugose, near snuff brown (R) in young specimens, becoming between mouse gray (R) and deep mouse gray (R) in old ones. Margin nearly concolorous but may be of a lighter shade in young specimens.

Crust (Plate 29, fig. 2) usually very distinct, blackish, hard, in older specimens ranging between 1 and 3 millimeters

¹⁵⁸ Western Polypores (1915) 29.

thick, cracking in age and tending to flake away. In young specimens, however, it may be comparatively thin (about 0.5 millimeter), occasionally entirely lacking at or near the growing margin.

Context corky, very thin or thick, from 4 millimeters to 4 centimeters, varying in color from Mikado brown (R), in young specimens, to chestnut (R) or bay (R). Young specimens have a distinct silky sheen on smooth cuts. Zonation usually lacking where the context is thin and present where thicker. The hard black lines so conspicuous in *applanatum* are not usually very noticeable in this variety or may be entirely lacking or replaced by softer poorly developed lighter ones similar to those in variety *philippinense* of the East.

The lower surface in dry unsublimated specimens may be somewhat flavous, passing through avellaneous (R) to somewhat darker than snuff brown (R), or even blackish discolored; brown on bruising.

The pores (Plate 23, fig. 1; Plate 25, fig. 3; Plate 30, fig. 2; Plate 31, fig. 3) are comparatively long, up to about 2 centimeters, indistinctly layered, with a total length up to 6.5 centimeters. They offer nothing distinctive in color, varying around benzo brown (R) and Verona brown (R). The mouths may be circular to angular, more commonly subangular. The walls vary from medium to thick, with entire edges. In size they may vary up to 100 per cent in the same specimen, averaging 3.9 to 4.7 to a millimeter, with an average of 4.3 for the series of seven specimens.

Seven specimens were examined for ratio of pore-wall thickness to diameter of pores. In seventy measurements the walls varied from 70 to 417 μ and the openings from 139 to 417 μ , the average ratios for the seven specimens being 1: 0.85, 1: 0.91, 1: 1.06, 1: 1.06, 1: 1.32, 1: 1.40, and 1: 2.10. The walls, therefore, may be somewhat thicker, nearly equal to, or less than one-half the diameter of the opening.

The spores (Plate 33, figs. 9 to 12) when young are from olive buff to deep olive buff, the mature ones being deep olive buff to dark olive buff, with fine to coarse distinct striæ, for the most part coarse. They are the largest in the *applanatum* group, the average for crushed mounts from nine specimens (one hundred thirty measurements) being 7.60 by 11.62 μ and for spores from the upper surface of three specimens (thirty measurements), 7.92 by 12.46 μ . The spores in the Javan specimen (Plate 33, fig. 12) average 9.2 by 13.2 μ from the crushed

mount; in Baker's *Pacific Slope Fungi* 339 they average 9.6 by 13.0 μ .

SPECIMENS EXAMINED

UNITED STATES, California, Berkeley, University campus, on living *Umbellularia californica*, C. J. Humphrey, "A," "B," 3199, 3200, 4575 (H), on dead stub of *Quercus agrifolia*, 5972 (H); San Francisco, Muir Woods, Mrs. C. J. Humphrey, "C" (H); Santa Clara County, foothills near Stanford University, on living *Quercus agrifolia*, C. F. Baker 339 (B).

Canary Islands, Teneriffe, J. Bornmüller, *Pl. exs. canarienses* 1900, No. 45.

Java, Buitenzorg, Botanical Garden, on stem of *Cinnamomum*, C. van Overeem 161 (Bg).

GANODERMA APPLANATUM (Pers.) Pat. var. *LAEVIPOSPORUM* Humph. var. nov.

At the higher elevations in the Philippines there occurs a distinct variant of *applanatum* with the mature spores entirely devoid of striæ in the walls. Although other forms or varieties of *applanatum* in the Orient, particularly *tornatum*, may have some nonstriate spores occasionally mixed with striate ones in young specimens, this variety is different in having no trace of striæ either when derived from the crushed mount or when taken from the upper surface. It is an established condition, therefore, worthy of a separate varietal name.

The two specimens mentioned under the discussion of Japanese collections of *applanatum* are analogous and may eventually require segregation, but the general characters of the sporophores are too near *applanatum* to justify the writer in separating them at present. The Philippine and Javan collections fall into a definite category on other characters also. There is still another smooth-spored variant of *applanatum* of the form of *annulare* Lloyd, but since we have not yet seen the type of *annulare* this variety will not be treated until a later paper.

The variety under discussion (Plate 7; Plate 29, fig. 3) is sessile and varies from thin and applanate to compressed unguulate. The largest specimen is 5.25 inches wide and shelving for 2.5 inches. The maximum thickness at the base is 4 centimeters, but young, thin, applanate specimens are less than 1 centimeter.

The upper surface is somewhat convex to nearly plane, lightly sulcate, nearly even, occasionally finely rimose, nearly unicolorous, varying from pale brown to Sayal brown (R) or Verona brown (R). Margin subacute to abrupt and sulcate.

The context (Plate 26) is corky, or quite hard just beneath the crust, Verona brown (R) to auburn (R) or bay (R), frequently tinged with clay color (R) just beneath the crust; maximum thickness 2 centimeters at the base of one specimen but the other specimens are less than a centimeter and frequently only 3 to 4 millimeters. It is one of the thin context forms like *tornatum* in which the context is well supplied with distinct hard black streaks and not concentrically sulcate.

The under surface is quite variable. Young specimens may be near chamois (R). Others fluctuate from between avellaneous and wood brown (R) to near buffy brown (R). In one of the collections the color is light grayish olive (R). A peculiarity of several is that they bruise to a light vinaceous gray (R) or purplish.

The pores (Plate 23, figs. 2 and 3; Plate 26; Plate 30, fig. 3; Plate 31, fig. 4) in longisection are quite uniformly Verona brown (R). They are usually subangular to angular, occasionally circular, with the dissepiments thin to medium, entire to somewhat eroded. They are fairly uniform in size and average 5.5 to the millimeter for thirty measurements on five specimens from different collections. The walls range from 7 to 70 μ in thickness and the pores from 83 to 208 μ in diameter, the average ratios for seven specimens being 1 : 2.67, 1 : 3.00, 1 : 3.30, 1 : 3.36, 1 : 3.87, 1 : 3.93, and 1 : 5.90, respectively. The pores, therefore, are much greater in diameter than the thickness of the walls.

The spores (Plate 34, figs. 1 and 2) in Philippine material are usually abundant, ovate, with no trace of striæ, and vary in color in potash mount under the high power of the microscope from olive buff to dark olive buff. Those from the crushed mount average 4.97 by 8.62 μ (fifty measurements from five collections) while the ones from the upper surface are 5.69 by 8.92 μ (forty measurements from four collections.) The spores in the Javan specimen average 5.3 by 8.9 μ .

An anomalous condition exists in two of the collections. In 705 from Java are two specimens which, except for the thinner-walled pores, color of context, and spores, would unquestionably be considered the same. The one has a russet context, thick-walled pores, which are near dark vinaceous drab in longisection, and striate spores, 6.1 by 9.3 μ , and must be referred to *tornatum* forma *macrospora* of the present classification. The other (Plate 7, figs. 18 and 19) has a Verona brown context, rather thin-walled pores somewhat paler than the context, and

smooth spores, 5.3 by 8.9 μ , and is referable to variety *laevisporum*. In Bureau of Science collection 7637 from Mount Apo, Mindanao, one specimen can be separated from the other three on exactly the same characters. Of these three, one specimen has spores that are just beginning to form striæ; in the others the spores are more mature and distinctly striate. Those plants with striate spores are referable to *tornatum* forma *macrospora*. There is no direct evidence that the two kinds of sporophores were directly associated in nature but if so the situation is rather novel. There are too many instances of mixed collections, however, to warrant an assumption one way or the other.

Of the specimens cited, 50084 and 50085 are designated types of the variety.

SPECIMENS EXAMINED

JAVA, West Java, Tjibodas, G. Gedeh, *C. and D. van Overeem de Haas, Dalkus, Bruggeman and W. D. van Leeuwen* 705 (*pro parte*) (Bg).

PHILIPPINE ISLANDS, Luzon, Mountain Province, Benguet Subprovince, Baguio, *E. B. Copeland* 1039, on *Pinus insularis*, 1303 (B), Haight's Place, 50085, Pauai, 8738; Bontoc Subprovince, Mount Data, mossy forest, *M. S. Clemens* 50084, along high forest trail, on *Quercus jordanae?*, *M. S. Clemens* 50086. Mindanao, Davao Province, Mount Apo, *M. S. Clemens* 7637 (*pro parte*).

GANODERMA APPLANATUM (Pers.) Pat. var. PHILIPPINENSE Humph. var. nov.

Practically all the broadly applanate sessile variants of *applanatum* in the Philippines fall in the two varieties *tornatum* and *philippinense*, of which the latter may well be considered an analogue of the North American form of *applanatum*, although it is considerably more variable. The two varieties mentioned can, as a rule, easily be segregated on one or more of several characters. Separation of *philippinense* from the base species, however, is more difficult and there are forms referred to the variety in the present paper upon which all investigators might not agree as to the propriety of segregation. However, since we are primarily dealing with a Philippine thing that in its usual development is sufficiently marked as a strong variety it is better to err by placing in the variety those forms that approximate the base species rather than to broaden the limits of the base species and thus increase the difficulties of interpreting between the two locally. In other words, this is a case where geographical considerations can be invoked to clarify somewhat the nomenclatorial situation.

In discussing variety *philippinense* as here constituted the writer is constrained to include within it forms that show very wide end variations, since these all run together in any reasonably large series of collections. One could easily pick out three or four of the most distinctive forms that mycologists not conversant with Philippine variations would probably not hesitate to consider distinct species, or might even refer to certain of the older species. Should the writer attempt to segregate them at present it would be as forms rather than varieties, and forms in the *applanatum* group are too numerous to warrant encumbering the literature. Various workers who have identified material for the Bureau of Science and the Baker herbaria have given different interpretations. Bresadola has consistently referred such Bureau of Science specimens as he saw [10556 (Plate 8, fig. 6; Plate 34, figs. 5 and 6) 13751, 16634 (Plate 9, fig. 6), 19239] to *Ganoderma subornatum* Murr., except 10538, which he placed in *megaloma* Lév. Elmer distributed as *Fomes gibbosus* (Bl. and Nees) Pat. (14255) a very young stipitate atypical specimen whose affinities lie with the variety. Lloyd has used various specific names such as *applanatum* Pers. [35867 (Plate 12, fig. 9; Plate 23, fig. 9), 35998 (Plate 8, fig. 7)], *australe* Fr. [16634 (Plate 9, fig. 6), 19239, 35999 (Plate 8, figs. 3 and 4), the first two being *subornatum* for Bresadola], *fasciatum* Lév. (28308), *koningsbergii* Lloyd (2094 from Borneo), *leucophaeum* Mont. [35977, 35997, 36094 (Plate 8, fig. 5)], *oroflavus* Lloyd [36046 (Plate 14, figs. 5 and 6; Plate 27, fig. 2), 36097], *tornatum* Pers. [36007 (Plate 9, fig. 5)], *Fomes lamaeensis* Murr. (Baker 29), and *Fomes pachyphloeus* Pat. (Baker 460). Murrill referred his specimens to *Elfvigia tornata* (Pers.) Murr. (167, 8932), the latter number being *koningsbergii* for Lloyd. Patouillard used the following names in the Baker herbarium; *australe* Fr. (659, 3353), *leucophaeum* Mont. [670, 714 (Plate 8, figs. 15 and 16), 763, 4215, 4381], and *mastoporum* Lév. (762). Sydow placed one small grayish specimen (18388) in *testaceum* Lév. (Plate 9, figs. 10 and 11). It is hoped that the illustrations (Plates 8 to 14; Plate 29, fig. 4) will serve to convey to the reader a better conception of these forms than can be gained from the general description that follows.

In the commoner form the plants are applanate, nearly plane to broadly convex, and sessile. Distinctly laterally stipitate forms frequently occur, however, the stipe being long and torulose at times (Plate 11, figs. 1 to 4), often curving downward when attached to roots. The earliest stages of growth (Plate

9, figs. 12 and 13; Plate 12, figs. 6 to 8) often appear as hemispheric, subglobose, compressed-ungulate, or ungulate masses of compact sterile hyphæ, which may reach a thickness of 8 centimeters. Other young stages that are beginning to take on the applanate form may be somewhat concave above (Plate 10, figs. 5 and 6). Ultimately the sporophores attain a large size and are conspicuous in the forest, the largest specimen at hand being 15 inches long and 22.5 inches broad, although larger ones are not unusual.

The upper surface is characteristically tuberculose, occasionally radiately grooved, frequently somewhat sulcate but usually not strongly so. The color usually ranges from pale brown to dark brown, although occasional specimens may vary from pale smoke gray (R) and smoke gray (R) to shades of drab, or even blackish (Plate 17, fig. 9). In this respect they are not much different from the base species. Some of the younger specimens, however, which are considered by Patouillard as *Ganoderma leucophaeum*, are quite distinctive, the extreme margin being light buff (R), followed by deep purplish gray (R) shades (Plate 8, figs. 15 and 16). These latter shades have not been observed in the base species.

The context usually varies from soft corky to corky, often quite hard behind, its color being usually around russet (R). The lightest shades noted were near fawn color (R) and avellaneous (R) and the darkest were auburn (R) to near chocolate (R). Other intermediate shades are cinnamon (R), Sayal brown (R), Verona brown (R), and army brown (R). As a rule the colors in a single specimen are not uniform but consist of two or more, shading one into the other, the shade next to the pore layer usually being the darker. Indistinct to striking concentric bands of lighter and darker tissue are frequently present. The harder black radiating streaks so common in *Ganoderma applanatum* are sparingly represented. Many specimens, however, have more or less radiating streaks or distinct bands of tissue that are near fawn color (R) and only slightly harder than the surrounding darker tissue. Being more abundant at the base they tend to make the tissue in that region firmer. Other specimens may be devoid of streaks of any character, particularly the younger ones.

One fairly constant feature of the context is the presence of distinct whitened flecks or areas from the size of a pin head to several millimeters. These vary around cartridge buff (R) or may be more ochraceous. They are frequently associated with

cavities, apparently produced by insects, and take the form of isolated more or less circular areas or somewhat elongate streaks running in the direction of the fibers, or concentrically along the zones. Occasionally they are sufficiently numerous to coalesce and give a distinct bleached effect to the context. These bleached areas consist of very fine hyphæ, colorless under the microscope (Plate 28).

The pore surface when fresh may be nearly white in some specimens, brownish on bruising, while sporophores growing adjacent to them may vary from deep purplish gray (R) to blackish slate (R). The light surfaces darken somewhat in drying and the dark ones become somewhat lighter. The light-colored ones range from pallid brownish to wood brown (R) and Verona brown (R). One young specimen was near light buff (R) and young superimposed growth on the under surface of an old black sporophore was near tawny olive (R). Occasionally the same sporophore will be pallid brown on the outer portion and benzo brown (R) to near Verona brown (R) behind. When dry the dark under surface varies around mouse gray (R), deep brownish drab (R), and fuscous (R).

Photomicrographs of sections made at the extreme tips of the pores of type specimens having light and dark under surfaces (Plate 27, figs. 4 and 5), respectively, show that the tissue of the light ones is composed of thin-walled, rather fine, closely interwoven, colorless hyphæ, while in the dark ones rigid, thick-walled, more or less parallel, brown hyphæ extend to the very end of the dissepiment, pushing through a narrow zone of the colorless ones. This differentiation of hyphæ at the tips apparently indicates a more mature condition of pore development and may be considerably influenced by climatic conditions prevailing at different stages of growth.

The pores in longisection (Plate 27, figs. 1 to 3; Plate 31, fig. 5) may be corky in young specimens and hard in older ones; in general they are harder than those of *Ganoderma applanatum* from the United States and Europe but do not differ from Japanese and Brazilian material in this respect. The color is fairly uniform. Young partially developed layers may be avellaneous (R); older ones vary around Verona brown (R) and Mars brown (R) to benzo brown (R). Occasionally they become bleached.

In shape the pores (Plate 23, figs. 4 to 17; Plate 30, fig. 4) vary from circular to angular, in large part subangular, with thin to thick dissepiments (more commonly medium to thick),

usually entire, occasionally slightly eroded. The openings frequently vary 100 per cent in size (ratio 1 : 2). The number per millimeter varies from 4.9 to 6.1 (only one with this high count, the next highest being 5.8), the average for one hundred twenty-six counts on twenty-one different sporophores (with the exception of two, from different collections) being 5.4.

Thirteen representative specimens were examined for ratio of pore-wall thickness to diameter of opening. In one hundred twenty measurements the walls varied from 42 to 348 μ and the openings from 83 to 348 μ , the average ratios for the thirteen being 1 : 0.50, 1 : 0.69, 1 : 0.74, 1 : 0.77, 1 : 0.77, 1 : 0.83, 1 : 0.85, 1 : 1.04, 1 : 1.26, 1 : 1.39, 1 : 1.46, 1 : 1.64, and 1 : 1.72.

There is a very hard form (Plate 14, figs. 1 to 3, and 7) of this variety that is occasionally found in various parts of the Islands. This offers nothing distinctive in shape or lower surface characters, although the upper surface tends to the more somber shades of brown to blackish. The context, however, becomes very hard and has a generally yellowish brown appearance, due to a higher percentage of tawny olive (R) and cinnamon brown (R) in the blend of colors; there is occasionally, however, a minor proportion of russet characteristic of the typical forms of the variety. There are up to two layers of pores in the specimens at hand, but these fall well within the limits of the variety in hardness, shape, and size. The spores (Plate 34, fig. 8) are the same.

Another distinct form (Plate 14, figs. 4, 8, and 9; Plate 34, fig. 9) is large, applanate, sessile or with a short, horizontal, lateral stipe. Context typical. Upper surface with a thick hard crust that becomes shining black on rubbing but is dusted with fawn-colored to wood brown spores and other fine particles. The pore surface (Plate 23, fig. 12) is near light grayish olive (R) to near mouse gray (R), bordered all around by a sterile brown band 5 millimeters to 2 centimeters wide. This broad sterile margin is a rather unusual feature, but is present to a lesser degree in other specimens of the variety.

Specimens that the writer takes to be a young condition of the variety (Plate 13, figs. 1 to 11) are rather light weight with a thin brownish to black crust easily indented with the finger nail, the upper surface being somewhat finely rimose, somewhat sulcate, occasionally lightly tuberculose, and variously obscurely banded with shades of smoke gray, drab, and benzo brown (R). The pore surface is always whitish when fresh, indicating a young growing stage, but becomes very pale brownish to near

wood brown (R) on drying; buffy brown (R) to chocolate on bruising. The context varies from cinnamon (R) and Sayal brown (R) to russet and is soft corky, with black streaks very rare and the fawn-colored ones scarcely represented.

Three large typical specimens of the variety from the Federated Malay States (Plate 11, figs. 3 to 7, 9, and 10; Plate 34, fig. 12) were represented among the *Ganodermas* loaned by the Singapore Botanical Garden. One of the two applanate specimens had the usual dark under surface; the lower surface of the other was near cartridge buff (R). The third specimen (Plate 11, figs. 3 and 4) was younger, with a nearly circular, slightly concave pileus about 14 centimeters in diameter and an ascending torulose stipe 5 centimeters thick at the base, 3.5 centimeters at the top. Upper surface lightly sulcate, not tuberculose, with a thin brown crust zoned with light buff (R) at the edge and alternating bands of wood brown (R) and vinaceous drab (R) behind. Context corky, harder at the base of the stipe, distinctly concentrically zoned throughout pileus and stipe, of a general russet color with suggestions of ochraceous tawny just beneath the crust, 5 centimeters thick at the gibbous attachment of the stipe, with abundant fawn-colored streaks throughout the stem but not in the pileus proper. The stipe was distinctly tuberculose, near cinnamon drab (R) below and near light mouse gray (R) above, covered by a dark brown to blackish, glabrous, dull crust. Under surface light buff with a brownish tinge, with circular to subcircular thick-walled pores 9 millimeters long and averaging 5 to the millimeter, devoid of spores.

The senior author is of the opinion that such forms as these are what Blume and Nees ¹⁵⁹ described and figured in color from Java as *Polyporus gibbosus*, but they certainly cannot be distinct from the strictly sessile broadly applanate forms that are much commoner. The type probably not being in existence it is impossible to determine just what Blume and Nees had in hand. Nothing to closely match their figures has ever been seen by the writers, and if at all common it would probably be represented in the Buitenzorg collections. It seems advisable, therefore, to drop the name.

The two specimens in the senior author's herbarium from Java are rather doubtfully referred to *philippinense*. Both are comparatively young and could with nearly equal propriety be

¹⁵⁹ Fungi Javanici, in Nova Acta Acad. Caes. Leop. 13 (1826) 19, pl. 5.

left in the base species. In fact Dr. E. A. Burt has identified 5479 (Plate 12, fig. 12) as *applanatum*. Further collections from Java are necessary before it can be decided whether the variety is properly represented in the Dutch East Indies.

The spores (Plate 34, figs. 3 to 12) of variety *philippinense* are very similar to those of the base species, varying under the microscope (high power) from olive buff to dark olive buff, for the most part with fine to moderately coarse, quite distinct, striae. Occasionally a specimen has somewhat coarser ones. They are thus similar in these respects to the spores of many collections of *applanatum*, particularly those from the United States. They are frequently collapsed when taken from dry specimens, but this is nothing distinctive. In fact, the spores of many specimens of *applanatum*, those of *mastoporum*, of variety *philippinense*, and of *tornatum* forma *macrospora* are too much alike to separate by any descriptive terms.

Measurements made on variety *philippinense* from the Philippines gave an average of 5.43 by 8.77 μ for 534 spores from the crushed mounts of 47 collections, while those from the upper surface averaged 6.16 by 9.45 μ for 360 measurements from 34 collections. The two specimens from the Federated Malay States gave 5.8 by 8.9 μ from the crushed mount of one and 5.9 by 9.1 μ from the upper surface of the other.

Bureau of Science 50047 is designated as the type (Plate 9, fig. 15; Plate 10, figs. 1 to 7; Plate 23, figs. 5 and 6; Plate 27, figs. 4 and 5) since at least four of the principal forms are represented among the several sporophores. No. 50048 may be considered as supplementary to represent more fully the form with dark under surface.

In his paper on New Zealand Polyporaceae Cunningham¹⁶⁰ recognizes three species and one variety of the *applanatum* group; namely, *Fomes applanatus* (Pers.) Gillet, *Fomes australis* (Fr.) Cke. and its variety *oroflavus* (Lloyd), and *Fomes subternatus* (Murr.) Lloyd. He distinguishes between them on the relative size of the pores, stating that the walls of the tubes are 0.09 to 0.1 millimeter (90 to 100 μ) thick in *applanatum* and *australis*, with tubes 0.18 to 0.2 millimeter (180 to 200 μ) in diameter in *applanatum* and 0.27 to 0.3 millimeter (270 to 300 μ) in *australis*. In *subternatus* the walls are given as 0.2 to 0.25 millimeter (200 to 250 μ), with no data on the diameter of the tubes. The writer has attempted to apply these

¹⁶⁰ Trans. N. Z. Institute 58 (1927) 214-218.

criteria to the various species and varieties described in the present paper, the data being presented under the respective names. With the exception of *subtornatum*, all of Cunningham's figures fall within the limits of any of the species or varieties described, except *applanatum* from Australia, but including *applanatum* from Europe. Likewise our figures cannot be considered of diagnostic value in differentiating species or varieties. It may also be remarked that Cunningham's *Fomes australis* is not the same as our *tornatum*, which has considerably smaller spores. Likewise his *Fomes subtornatus* differs in spore characters from anything the senior author has seen, although the illustrations seem to agree fairly well with what we consider variety *philippinense*.

SPECIMENS EXAMINED

BRITISH NORTH BORNEO, Sandakan, Sibuguey, *M. Ramos* 2094.

FEDERATED MALAY STATES, Johore, Pontian Road, on fallen trunk in rubber plantation, *E. J. H. Corner* 23225 (S); Pahang, Bantong, on an old stump, May, 1930, *E. J. H. Corner* (S), Fraser Hill, *E. J. H. Corner*, 23229 (S).

JAVA, Buitenzorg, on *Acacia decurrens*, *Carl Hartley* 5479 (H); West Java, on *Vernonia arborea*, *Carl Hartley* 5410 (H).

PHILIPPINE ISLANDS, BASILAN, Isabela, *H. S. Yates* 35998, 35999, 36007, 36046, 36094, 36097, 36116. BILIRAN, *R. C. McGregor* 18388. LUZON, no locality given, *Father Sanchez* 45881, 50063; Albay Province, Catanduanes Subprovince, *M. Ramos* 50076; Bataan Province, *H. M. Curran, Bureau of Forestry* 19239, Mount Mariveles, *C. J. Humphrey* 50077, on *Shorea guiso* (Blco.) Blm., *C. J. Humphrey* 50048, 50069, 50070, *C. J. Humphrey and L. Reyes* 50094, on *Pentacme contorta*, *C. J. Humphrey and L. Reyes* 50057, Samal, *M. S. Clemens* 1305; Cagayan Province, *H. M. Curran, Bureau of Forestry* 16634; Camarines Sur Province, Botol River, *G. Edaña* 50049; Laguna Province, Los Baños, *C. F. Baker* 659A (B), 29 (B), 714 (B), 762 (B), 763 (B), Mount Maquiling, *C. F. Baker* 3353 (B), 4215 (B), 4381 (B), on dead branches of *Parashorea plicata*, *J. Daproza* 460 (B), *Alejandro de Mesa and Conicosa* 50051, *C. J. Humphrey* 50044, on *Alphonsea arborea* (Blco.) Merr., *Alejandro de Mesa and Conicosa* 50042, 50043, on *Canarium ovatum* Merr., *C. J. Humphrey* 50045, on *Diplodiscus paniculatus*, *Alejandro de Mesa and Conicosa* 50071, on *Parashorea malaanonan*, *Alejandro de Mesa and Conicosa* 50046, *C. J. Humphrey* 50047, 50052, 50053, 50054, 50068, on timber, *Buenaventura Reyes* 50055, 50067, V.

Serviñas 16930 (B. S.; B), Santa Maria Mavitac, *H. M. Curran, Bureau of Forestry* 8932; Mountain Province, Apayao Subprovince, Aguimi, *E. Fenix* 28308 (B. S.; B); Pampanga Province, Mount Arayat, *R. C. McGregor* 42075, 42078, Stotsenburg, *M. S. Clemens* 2325, 2578; Rizal Province, Mayatagan River, *G. Edaño* 50103; Sorsogon Province, Irosin, Mount Bulusan, *A. D. E. Elmer* 15986 (B. S.); Tayabas Province, *R. C. McGregor* 47956, Calauag, *O. Ladia* 50124, Guinayañgan, *O. Ladia* 50106, *O. Ladia* and *Jundak* 50105, *O. Ladia*, *Jundak*, and *Alejandro de Mesa* 50072, *M. Oro* 50127, on *Dipterocarpus grandiflorus* Blanco, *O. Ladia* 50058, 50062, 50109, 50110, 50118, 50122, *M. Oro* and *Jundak* 50123, on *Livistona* sp., *M. Oro* 50050, on *Livistona rotundifolia*, *O. Ladia* 50121, on *Parashorea malaanonan*, *M. Oro* and *Jundak* 50108, near Kabibihan, *C. J. Humphrey* 50073, 50074, 50075, Malicboy, *R. C. McGregor* 47960; Zambales Province, Castillejos, *M. S. Clemens* 3289, Olongapo, *M. S. Clemens* 4548, 4551, 50064, 50065. MINDANAO, no locality given, *Alejandro de Mesa* 50056; Agusan Province, Cabadbaran, Mount Urdaneta, *A. D. E. Elmer* 13403, 14255 (B); Davao Province, Mount Apo, *M. S. Clemens* 50066; Zamboanga Province, *C. J. Humphrey* 50041, 50078, 50093, on *Pentacme contorta*, *C. J. Humphrey*, 50092, 50096, 12181 (H), 12184 (H), 12192 (H), *H. S. Yates* 35977, on *Pometia pinnata* Forst., *C. J. Humphrey* 50095, on *Shorea teysmanniana* Dyer, *C. J. Humphrey* 12173 (H), 50079, *Lumarao*, on *Palaquium* sp., *Alejandro de Mesa* 50059, on *Diospyros discolor*, 50061, Malangas, *M. Ramos* and *G. Edaño* 36477, Naga-Naga, *Alejandro de Mesa* 50060, 50080, on *Parashorea malaanonan*, *A. de Mesa*, 50107, 50119. NEGROS, Occidental Negros, Mount Marupa, *H. M. Curran, Bureau of Forestry* 13751. PANAY, Capiz Province, Mount Bulilao, *A. Martelino* and *G. Edaño* 35882, Mount Salibongbong, *A. Martelino* and *G. Edaño* 35865, 35867. POLILLO, *R. C. McGregor* 10538, 10556 (B. S.; B). SULU ARCHIPELAGO, Tawitawi Island, *H. S. Yates* 35943.

GANODERMA APPLANATUM (Pers.) Pat. var. TORNATUM Pers.

After a very critical study and careful comparison of many specimens of *Ganoderma applanatum* and its variants the writers have reached the conclusion that it is unwise to continue to maintain *Ganoderma tornatum* (*australe* Fr. of many writers) as a species. In its typical form it is sufficiently distinct from typical *applanatum* from Europe and the United States but when other parts of the world are brought into consideration, with

their intermediate forms that cannot be differentiated on a structural basis, there is too much of a general resemblance to warrant specific segregation. The temperate regions of the Orient, in particular, such as China, Japan, and the higher altitudes of the Philippines, produce too many confusing forms for safe classification on the old basis. While for the majority of collections the spores are a suitable criterion, still in a certain proportion of specimens that are typical *tornatum* in appearance one finds the spores of *applanatum* and, vice versa, there are occasional collections of what must be considered *applanatum* that have spores similar to, or very close to, *tornatum*.

Cleland and Cheel¹⁶¹ appear to have been the first to use the combination *Fomes applanatus* var. *australe* Fr., with reference to Australian specimens.

The senior author has a series of collections of the *applanatum* group from Doctor Cleland, and all but one are referable to the base species. The exception is placed in variety *tornatum* on the basis of its smaller typical spores, even though it is indistinguishable on other characters from *applanatum*, but it is not typical *tornatum* of the Tropics. Whether Cleland based his varietal concept on a knowledge of typical tropical forms we are unable to state. *Ganoderma australe* Fr. is apparently different from what we refer to *tornatum* since the only known type of the Friesian species has much larger spores.

Bresadola has examined the type of *tornatum* Pers. and refers to it certain Philippine¹⁶² material with spores usually 7 to 8 by 4.5 to 5 μ and a Javan¹⁶³ specimen with spores 6 to 8 by 4 to 5 μ . These measurements accord well with our concept of the variety.

Several of the specimens from the Philippines here referred to variety *tornatum* have been variously named by other workers. Bresadola referred the specimens sent him either to *Ganoderma australe* or *tornatum* [*Bu. Sci.* 193, 14376, 16028 (Plate 17, fig. 20)]. Graff used the names *applanatum* [*Bu. Sci.* 14376 (Plate 17, fig. 24; Plate 35, fig. 1), 16390] and *subtornatum* (19234). Lloyd employed more names than anyone else, referring specimens to *applanatum* [*Bu. Sci.* 193, 14376, 16028, 19236 (Plate 24, fig. 5), 21596 (Plate 35, fig. 4), 27832, 35962, 35969, 36061; *Baker herb.* 3582, 3614, 3634 (Plate 19,

¹⁶¹ Proc. Roy. Soc. N. S. Wales 51 (1918) 518.

¹⁶² Hedwigia 53 (1912) 55.

¹⁶³ Ann. Myc. 10 (1912) 502.

fig. 1), 4130, 4187, 4211, 4357, 4364, 4374, 6018, 9602, 9621], *australe* (Bu. Sci. 16930, Baker 9796), *gibbosum* (Bu. Sci. 19234, Baker 5110), *nigrolaccatum* (Baker 9683), *tornatum* [Bu. Sci. 36121, 36130 (Plate 16, fig. 3)], *williamsianum* Murr. [Baker 2955 (Plate 35, fig. 3)], and *Fomes lamaoensis* Murr. (Baker 75). Murrill used *Elfvingia tornata* (Bu. Sci. 193). Patouillard applied the four names *applanatum* (Baker 2480, 7383), *australe* [Baker 512, 659 (Plate 17, fig. 25), 2518 (Plate 30, fig. 6), 3388, 3393, 3415 (Plate 35, fig. 5), 4461 (Plate 17, fig. 26)], *testaceum* [Baker 1662 (Plate 19, fig. 5)], and *tornatum* (Baker 2119, 2613, 2735). Sydow determined one specimen as *australe* [Bu. Sci. 14376 (Plate 17, fig. 24; Plate 35, fig. 1)] and one as *tornatum* (Bu. Sci. 18341).

Of the material from the Singapore herbarium Lloyd determined two specimens. One (8354) he called *Fomes fasciatus* Lév., the other (4935) *leucophaeus*. Miss Wakefield named the Bornean specimen [19202 (Plate 35, fig. 8)] *Ganoderma australe* (Fr.) Pat. None of the Buitenzorg specimens were determined.

The sporophores (Plates 15 to 17, figs. 1 to 8, 10 to 26; Plate 18; Plate 19, figs. 1 to 8, 11 to 17) are predominantly applanate, often rather hard and heavy, broadly convex to nearly plane, for the most part sessile, dimidiate and rather thin, usually with a thin context and relatively long pores. The shape, mode of attachment, and relative weight vary to a considerable extent, however. The thickness of the context may also show wide variation, particularly in the younger specimens; in fact, it is often quite impossible to discriminate between the species and the variety on this character, although the older typical specimens can for the most part easily be segregated by the comparatively thin context and relatively long pores.

Among the smaller specimens laterally stipitate to substipitate forms are not unusual. Sessile forms, on the other hand, may be broadly attached or effused behind for more than the length of the pileus. An occasional collection may be subungulate. In rare instances sterile hemispherical masses (Plate 19, figs. 11 and 12) may occur; one such measured 2.25 inches in diameter. These are not likely to be confused with variety *philippinense*, however, on account of their darker internal color and the presence of harder black streaks instead of the fawn-colored ones prevalent in *philippinense*.

Three of the largest Philippine specimens measured 12 by 8 by 1½, 11 by 9.5 by 1.75, and 11 by 7.5 by 2.5 inches in width,

length, and basal thickness, respectively, while a large Malayan specimen measured 13 by 6.5 by $\frac{7}{8}$ inches. Some of the small specimens were only 0.25 inch thick. The greater number of specimens at hand showed only one or two layers of pores, these often being indistinctly separated. Occasionally a sporophore produced a new layer of pores upon the blackened surface of the old as an interrupted growth only partially covering the surface (Plate 15, fig. 2). At times this old tissue was dead and insect-riddled at the margins (Plate 15, fig. 3). Such superimposed pore layers were sometimes loosely joined, with a rather thick conspicuous vegetative layer of hyphæ between, thus producing the condition upon which *Fomes vegetus* Fr. is based.

The upper surface is lightly to strongly sulcate, for the most part rather uniform in color but sometimes obscurely zoned. It may be somewhat tuberculose or radiate rugose but this feature is not very noticeable, being masked by the strongly sulcate tendency, which immediately attracts the attention.

There is not a great variation in color, the younger specimens often being lighter in shade than the older. Here the colors range around wood brown (R), although some are close to Verona brown (R). Weathered young specimens may be near light drab (R) or near drab gray (R), with or without neutral gray (R) zones. Other young specimens may be near fawn color (R) or wood brown (R) to near snuff brown (R), often with paler brown zones or a few blackish ones. The margin may be somewhat paler, or even darker, than the general color, but this is not a conspicuous feature. Older specimens may occasionally be somewhat lighter than wood brown (R) but usually vary around Verona brown (R). Occasionally they may have a purplish gray cast.

The under surface color is highly variable, becoming darkened by weathering, bruising, or sublimating. Dried specimens collected in fresh growing condition and not poisoned with an alcoholic solution of corrosive sublimate vary from a dirty whitish with a pale vinaceous tinge to deep olive buff (R) or dark olive buff (R); on bruising they become Verona brown (R). Other miscellaneous collections vary around wood brown, sometimes paler, sometimes darker. One specimen was almost dark purplish gray (R) and still another dark purplish drab (R), which colors are common in variety *philippinense*.

The context is corky to very firm, or even hard in certain specimens where the black lines are abundant. The color varies

from sayal brown (R) to bay (R) or chestnut (R). Many are around russet (R), sometimes with paler zones. The colors, however, may be mixed in the same specimen; in one case they were sayal brown (R) above shading into bay (R), while in another both russet and bay were represented. Where differences in color exist in the same sporophore the darkest shade occurs just above the pores, but may be elsewhere as well. Obscure to distinct concentric zones are frequently present, especially in the specimens with the thicker context, and occasionally one finds small bleached spots around insect burrows, as in variety *philippinense*. Hard black streaks are almost invariably present, at least toward the base. The softer fawn-colored streaks of *philippinense* are rarely represented, and then only in association with the black ones. A black crust (Plate 25, fig. 4; Plate 29, figs. 5 and 6) is present in all specimens, varying from 0.25 to 1 millimeter thick and frequently cracked in dry specimens, often absent at the extreme margin.

The pores in longisection (Plate 25, fig. 4; Plate 31, fig. 6) vary around benzo brown (R), sorghum brown (R), Hays brown (R), and deep brownish drab (R), but the exact colors cannot be matched in Ridgway. They are frequently stuffed with white mycelium. In any case they offer considerable contrast to the context on freshly smoothed surfaces. As a rule, the dissepiments are quite similar in color to the thin dark context layer from which they arise, but the fact that the pores are pale within gives a general effect of contrast with the usually more brownish shades predominating in the context. The greatest number of layers observed was four, the maximum length being 27 millimeters. One centimeter, or a little less, is a good average figure for many of the specimens. As to hardness, the pores of some of the thin-walled younger specimens can easily be indented with the thumb nail, in this respect being similar to the usual American form of *applanatum*. Other, usually larger, specimens are firmer or quite hard, the latter being indented with difficulty.

In shape the pores vary from circular to angular, the usual condition being circular to subangular, only occasional ones being distinctly angular (Plate 24, figs. 1 to 6; Plate 30, figs. 5 and 6). The dissepiments vary from thin to thick and from entire to eroded, the greater number being medium to thick with the edges entire. The size usually varies within the same specimen from

25 to 50 per cent, but may be as high as 100 per cent. The number per millimeter varies from 4.9 to 6.4, the average for one hundred twenty measurements on twenty specimens being 5.7.

Fourteen representative specimens were examined for ratio of pore-wall thickness to diameter of opening. In one hundred forty measurements the walls varied from 28 to 348 μ and the openings from 83 to 348 μ , the average ratios for the fourteen specimens being 1: 0.40, 1: 0.93, 1: 0.97, 1: 1.24, 1: 1.36, 1: 1.47, 1: 1.60, 1: 1.75, 1: 2.16, 1: 2.26, 1: 2.51, 1: 4.23, 1: 4.51, and 1: 4.79, respectively.

The above description is drawn primarily from Philippine specimens. Material from the Dutch East Indies and from the Federated Malay States offers no further variation. One specimen from Togo, Africa, distributed by the Berlin Museum as *Fomes amboinensis* (Plate 19, fig. 6; Plate 24, fig. 6; Plate 25, fig. 4; Plate 35, fig. 11) readily falls in the variety both on spore characters and general appearance, while a single small specimen from Cuba is quite typical.

The spores (Plate 35) have a strong tendency toward elliptical, some being truncate at the distal end and a few having pointed hyaline tips. In many, however, these features are absent. Young spores are usually somewhat larger, at least longer, than the old, smooth walled or with indistinct striæ, paler in color and distinctly pointed ovate. Mature ones vary in color from olive buff to dark olive buff, but are usually the darker shades. The striæ are very distinct and moderately coarse to coarse, usually the latter. The hyaline epispore being relatively thin, the striæ are rather short, and being coarse, they gave a distinctly rough appearance to the spores. In size the spores are considerably smaller, and usually darker, than in *applanatum*.

Measurements were made of 1,078 apparently mature spores from crushed mounts of 93 Philippine collections. These gave an average of 5.03 by 7.58 μ , while spores from the upper surface of 53 specimens averaged 5.44 by 7.83 μ for 590 measurements.

Five specimens from the Dutch East Indies (Plate 19, figs. 7 and 8; Plate 35, figs. 8 and 9) averaged 5.16 by 7.62 μ for 47 measurements from crushed mounts and 5.63 by 7.93 μ for 20 measurements from the upper surface of 2 specimens.

Sixteen specimens from the Federated Malay States (Plate 19, figs. 14 to 17; Plate 35, fig. 10) averaged 5.97 by 7.83 μ for 137 measurements from crushed mounts; upper-surface spores

gave an average of 5.79 by 8.63 μ for 30 measurements on 3 specimens.

From the upper surface of the single Australian specimen (Plate 35, fig. 12) they averaged for 20 measurements 6.25 by 8.68 μ , thus being somewhat larger than normal for the variety, but altogether too small for Australian specimens of *applanatum*.

SPECIMENS EXAMINED

AFRICA, Togo, Misahöhe, *Baumann* (*ex Museo botanico Berolinensi*).

AMBOINA, *C. B. Robinson*, *Reliquiae Robinsonianae, Plants of Amboina, 2050* (B. S.).

AUSTRALIA, Queensland, Impie Forest, near Gympie, *J. B. Cleland* (6).

BORNEO, Banguet Island, *C. Boden-Klass 19202* (S.); *W. Koetai, F. H. Endert (2467) 6993* (Bg), *F. H. Endert (2463) 8636* (Bg).

CUBA, Ceballos, *Blanche and C. J. Humphrey 2817* (H; B. S.).

FEDERATED MALAY STATES, Johore, Gunong Pantai, *E. J. H. Corner 23238* (S); Pulau Penang, Waterfall Gardens, on stump of *Albizia lebek*, *T. F. Chipp 4985* (S), on dead wood, *M. Noor 5616* (S); Pahang, Tambeling, parasitic at base of *Hevea brasiliensis*, *E. J. H. Corner 23694* (S); Selangor, Kuala Lumpur, *C. Dover*, two unnumbered collections made in 1928 (S), on *Casuarina* stump, *T. F. Chipp 5673, 5677* (S), Lake Gardens, *M. Noor 5494* (B. S.); Singapore, Botanic Gardens, on dead *Bauhinia*, *Mat. 5144* (S), on rotten stump, *T. F. Chipp 5890* (S), *R. C. Holtum 11426* (S), Economic Gardens, on *Casuarina* stump, *Ethel M. Burkill 334* (S), Gardens Jungle, *R. C. Holtum 8354* (S), Woodlands, *Dr. L. Boon King 4935* (S).

JAVA, Boschproefstation, *J. W. Dorst (21) 5707* (Bg); Buitenzorg, Botanical Garden, *C. van Overeem 163* (Bg), *Nongnong 5537* (Bg), *5539* (Bg).

PHILIPPINE ISLANDS, BASILAN, Isabela, *H. S. Yates 36061*. LUZON, no locality given, *Alejandro de Mesa 50125*, *Father Sanchez 16206, 50001, 50008, 50010*; Bataan Province, *H. M. Curran, Bureau of Forestry 19234* (B. S., B), *19236*, Lamao, on *Ficus*, *E. B. Copeland 193*, *H. A. Lee 29*; Batangas Province, Mount Macolod, *A. P. Hitchens and W. I. Kelly 50018*; Cagayan Province, Aparri, *M. S. Clemens 2845*, Mount Camiguin, *G. Edaña 50036*, Tamdagan, *G. Edaña 50037*; Ilocos Norte Province, Bangui, *R. C. McGregor 6493*, Burgos, *M. Ramos 27832*; Ilocos Sur Province, Sevilla, *M. S. Clemens 1636*; Laguna Prov-

ince, Lilio, on *Artocarpus integra* (Thunb.) Merr., J. Conoza 50027, Los Baños, on bamboo stumps, C. F. Baker 512 (B), 659, (B), 1662 (B), 2119 (B), on *Artocarpus integrifolia*, 6018 (B), San Antonio barrio, on *Tamarindus indica*, N. Reyes 4130 (B), Majayjay, R. C. McGregor 50019, 50020, Mount Banahao, on *Dipterocarpus* sp., O. A. Reinking 4187 (B), 4211 (B), Mount Maquiling, C. F. Baker, unnumbered specimen collected January, 1914 (B), 75 (B), 2613 (B), 2735 (B), 3388 (B), 3393 (B), 4461 (B), W. H. Brown 16028, G. Cazeñas 2480 (B), on *Alphonsea arborea* (Blco.) Merr., Alejandro de Mesa and Conicosa 50015, 50016, on *Grevillea robusta*, D. Diviñagrancia 3415 (B), P. W. Graff 16017, R. Habaluyas 9796 (B), C. J. Humphrey 50014, on *Parkia javanica* (Lam.) Merr., 50028, on *Canarium ovatum* Merr., 50029, on *Parashorea malaanonan* (Blanco) Merr., 50030, 50031, on *Canarium ovatum* Merr., 50032, on *Alphonsea arborea* (Blco.) Merr., 50040, V. Marilao 9621 (B), S. Nantis 2518 (B), E. Quisumbing 3634 (B), O. A. Reinking 3614 (B), 4357 (B), 4364 (B), 4374 (B), 7383 (B), 9602 (B), J. Reyes 9683 (B), N. Reyes 3582, V. Serviñas 16930, Santa Cruz, on *Cocos nucifera* L., N. Reyes 2955 (B), on *Sandoricum koetjape* (Burm. f.) Merr., N. Reyes 5110 (B); Nueva Vizcaya Province, Dupax, R. C. McGregor 14376 (B. S.; B); Pampanga Province, Porac, M. S. Clemens 4583, Stotsenburg, M. S. Clemens 2280; Pangasinan Province, Umingan, F. Otanes 18341; Rizal Province, San Andales, F. Rivera 50011; Sorsogon Province, Irosin (Mount Bulusan), A. D. E. Elmer 15944, 16080 (B. S.); Tarlac Province, on *Mangifera indica*, M. S. Clemens 1596; Tayabas Province, Alabat, M. Ramos and G. Edaña 50005, 50009, Calauag, on *Dipterocarpus grandiflorus*, O. Ladia 50114, Guinayanangan, O. Ladia 50117, M. Oro 50111, 50113, on *Dasymaschalon clusiformum*, O. Ladia 50016, 50120, on *Parashorea malaanonan*, M. Oro 50115; Quezon, M. Ramos and G. Edaña 50006; Zambales Province, Castillejos, M. S. Clemens 3288, Olongapo, M. S. Clemens 4543, 4547, 4550. MINDANAO, locality unknown, Alejandro de Mesa 50033; Cotabato Province, Cotabato, on *Cocos nucifera*, C. J. Humphrey 50012, C. J. Humphrey 50038, Kabacan, on *Hevea brasiliensis*, C. J. Humphrey 50035, Sarunayan, C. J. Humphrey 50039; Davao Province, Mate, 50013, Mount Apo, M. S. Clemens 50081; Zamboanga Province, H. S. Yates 35966, 35969, 35972, on *Tarrietia javanica* Bl., 35962, 35979, on *Chisocheton* sp., 36121, on *Eucalyptus deglupta*, 36130, Lumarao, Alejandro de Mesa 50082, 50083, near Zamboanga, C. J. Humphrey 12161 (H), on *Cocos nucifera*, C. J. Humphrey

50017, 50034. NEGROS, Occidental Negros, La Carlota Experiment Station, J. M. Mendoza 50026; Oriental Negros, Zamboanguita, J. M. Mendoza 50025. PALAWAN, L. Escritor 21596 (B. S.; B.), Sir J. Brooke Point, vicinity of Imulnod, *Buenaventura Reyes* 50022, Kalbigo streams, M. Ramos and G. Edaña 50004, Mount Kabinbin, *Buenaventura Reyes* 50021, 50023, Mount Magkasaw, *Buenaventura Reyes* 50024, Puerto Princesa, R. C. McGregor 47929, Toba River, M. Ramos and G. Edaña 50003. PANAY, Antique Province, Culasi, R. C. McGregor 32663; Capiz Province, G. Edaña 50007, Libacao, A. Martelino and G. Edaña 35832, Mount Salibongbong, A. Martelino and G. Edaña 35866. POLILLO, Bulobalic, on *Diospyros* sp., M. Oro 50012. SAMAR, Loquilocon M. S. Clemens 6091, 6092, 50002.

GANODERMA APPLANATUM (Pers.) Pat. var. TORNATUM Pers. forma MACROSPORA Humph. f. nov.

When one examines a large series of *tornatum* specimens from the Orient a small proportion of them are found to have the same type of spores as *Ganoderma applanatum* var. *philippinense*, *Ganoderma mastoporum*, and some collections of *applanatum*. In other respects the plants (Plate 19, figs. 9 and 10; Plate 20; Plate 29, fig. 7) are inseparable from *tornatum*. It becomes necessary, therefore, to segregate these transitional forms for the convenience of other workers. The fact of spore differentiation here, reverting as it does to the base species, seems to the senior author added proof of the varietal relationship of *tornatum* to *applanatum*.

There are nineteen collections at hand, eight from the Philippines, two from the Federated Malay States (out of fifteen collections), and nine from Java (out of thirteen collections). The proportion from Java is, therefore, very high.

Of the Philippine material Lloyd was willing to call *Baker* 4174 either *australe* or *applanatum*, but considered *Bu. Sci.* 20389 (Plate 24, fig. 9) as *australe*. The Pahang specimen from the Federated Malay States (8479) he referred to *applanatum*. Only one of the Javan specimens (1619) was named and this Lloyd called *Fomes koningsbergii* Lloyd (Plate 20, figs. 9 and 10) with the note, "No. 88, *Fomes koningsbergii*, mss. now in printer's hands. It is very close to *Fomes leucophaeus* Mont. but has more minute pores and layers of resinous matter in its context."

With the exception of two stipitate specimens from Tjibodas, West Java [5819 (Plate 20, figs. 7 and 8) and 6211 (Plate 20, figs. 5 and 6; Plate 36, fig. 6)], which are better referable here

than elsewhere in spite of their being atypical, the sporophores are appanate and sessile. All are sulcate in varying degree, a number of them lightly tuberculose.

The context shows the usual variation of *tornatum* in color and consistency, and is relatively thin. In all but one specimen (Singapore 5722) hard black streaks were present. The Singapore collection was provided with only fawn-colored ones, in this respect approaching variety *philippinense*.

The under surface usually varied around wood brown (R). In one specimen, however, it was light buff (R), and in another near purplish gray (R). Occasionally there were tinges of olive buff or honey yellow.

The pores (Plates 24, figs. 7 to 9; Plate 30, fig. 7; Plate 31, fig. 7) were circular to subangular, with thick, entire dissepiments. There is a tendency in some specimens toward the *mastoporum* type; that is, with somewhat elevated orifice (Java, 5497, Bu. Sci. 2048). For Philippine material they averaged 5.6 to the millimeter. Three Javan specimens were 5.3, 5.6, and 7, respectively, with an average of 5.9.

Four Philippine specimens were examined for ratio of pore-wall thickness to diameter of pores. The walls varied from 70 to 348 μ thick and the pores from 70 to 278 μ in diameter, the average ratios being 1 : 0.41, 1 : 0.46, 1 : 0.82, and 1 : 1.25, respectively. It is thus seen that the walls are usually very thick as compared with the diameter of the pores, in this respect corresponding to the harder-pored specimens of *tornatum*.

Mature spores (Plate 36, figs. 1 to 6) varied from deep olive buff to dark olive buff, younger ones being somewhat lighter, and were finely to rather coarsely striate, mostly the latter. The average for seventy-six measurements from the crushed mounts of six Philippine collections was 5.81 by 9.36 μ and for seventy measurements from the upper surface of seven collections 6.40 by 10.15 μ . Four Javan collections gave an average of 6.05 by 9.39 μ for fifty measurements from the crushed mounts, and three collections averaged 6.10 by 9.31 μ for twenty-seven measurements from the upper surface. One specimen from the Federated Malay States averaged 5.63 by 9.62 μ for ten measurements from the crushed mount, and the other gave 5.85 by 9.10 μ from the upper surface. As a rule these averages are slightly larger than for variety *philippinense* but are too close to use as a factor in distinguishing between individual collections.

SPECIMENS EXAMINED

FEDERATED MALAY STATES, Pahang, Fraser Hill, upon the Selangor border, *I. H. Burkill and R. E. Holttum* 8479 (S), Tanah Rata, Cameron's Highland, *M. R. Henderson* 17808A (S); Singapore, Economic Gardens, *Kiah* 5722 (S).

JAVA, Oengeran Mountains, *W. Docters van Leeuwen* 1619 (Bg); West Java, Tjibodas, G. Gedeh, *Dr. Karny* 2706 (Bg), *Bruggeman* 5497, 5819, 6211 (Bg), *C. and D. van Overeem de Haas, Dakkus, Bruggeman and W. D. van Leeuwen* 705 (*pro parte*) (Bg).

PHILIPPINE ISLANDS, LUZON, Camarines Sur Province, Mount Isarog, *G. Edaña* 50089; Laguna Province, Majayjay, *R. C. McGregor* 50087, 50088, Mount Banahao, *C. F. Baker* 2945 (B), Mount Maquiling, *O. A. Reinking* 4174 (B); Mountain Province, Ifugao Subprovince, Mount Polis, 20389 (B. S.; B). MINDANAO, Davao Province, Mount Apo, *M. S. Clemens* 2048, 7637 (*pro parte*), 50066.

SUMATRA, West Coast, Bukit Batu Banting, *E. Jacobson* 5744 (Bg).

GANODERMA LOBATUM (Schw.) Atk.

This species was described by Schweinitz¹⁶⁴ from an abortive specimen collected at Salem, North Carolina, which is listed in his *Synopsis Fungorum* as 409-90. This specimen was examined by the senior author at the Academy of Natural Sciences, Philadelphia, Pa. It is rather young but sufficiently characteristic to be matched quite readily with later collections.

According to Murrill¹⁶⁵ the fungus occurs as far north as New York. The senior author has found it throughout the states south of Illinois, Indiana, and Virginia and west to Arizona. It also occurs in Cuba.

The plant was well described from Ohio by A. P. Morgan as *Polyporus reniformis*¹⁶⁶ and passed under this name for many years in American mycological literature. Overholts¹⁶⁷ also gives a very good description of it under *Fomes lobatus*. Curtis¹⁶⁸ remarked that it has a strong odor of fresh farina.

¹⁶⁴ Trans. Am. Phil. Soc. II 4 (1832) 157.

¹⁶⁵ North American Flora 9, pt. 2 (1908) 114.

¹⁶⁶ Bot. Gaz. 7 (1882) 135.

¹⁶⁷ Polyporaceae of the Middle-western United States, Washington Univ. Studies 3, pt. 1 (1915) 63-64.

¹⁶⁸ Am. Journ. Sci. and Arts II 9 (1850) 174.

Cooke¹⁶⁹ thought it to be the same as *Ganoderma incrassata* (Berk.) but no one else has expressed this opinion.

The fungus occurs on stumps, dead stubs, fallen trunks and limbs, and occasionally at the base of living trees, apparently having a preference for oaks and maples. It seems to be a wound parasite at times, attacking the roots and base of the trunk.

It is quite distinct from *Ganoderma applanatum* in appearance, habit of growth, and spores, one of its striking characters being the revival of the old sporophores and the production of new ones below. The old ones soon become insect riddled and gradually disintegrate. This has led to the view that the plant is strictly annual, but there is often too close a consolidation of the old and new pore layers to accept this view without reservations. Where perennial, however, there is always a distinct rather thick layer of sterile tissue separating the old from the new growth.

The sporophores (Plate 21) are applanate to compressed unguulate, usually sessile, rarely stipitate. The largest specimen at hand is 6.5 inches long, about 11 inches wide, and 2.25 inches thick at the base and is much like the usual large forms of United States *applanatum* in shape. The next largest specimen is 4 inches long, about 6 inches wide, and nearly 2 inches thick at the base. The margin may be subacute, blunt, or broadly rounded.

The upper surface is usually broadly convex, slightly to strongly sulcate, and may be somewhat tuberculose. The crust (Plate 27, figs. 6 and 7; Plate 29, figs. 8 and 9) is usually *soft* and *thin*, and easily crushed with the thumb nail. In a number of the specimens it is much cracked, and sometimes flaked away. Young specimens are often velvety pubescent and warm buff (R) at the margin, becoming argus brown (R) to near Mars brown (R) behind. One is cinnamon (R) to tawny (R). Older specimens vary around russet (R), argus brown (R), Verona brown (R), or warm sepia (R). Some are distinctly banded with these shades or with blackish. One is grayish behind, as in many specimens of *applanatum*, while another is almost black.

In general the context is relatively thick, spongy to corky, firm or even hard in certain of the older specimens abundantly supplied with the hard black streaks (Plate 25, fig. 6). These

¹⁶⁹ Grevillea 14 (1885) 21; 15 (1886) 58.

streaks are present in varying degree, however, in all specimens. The context color usually ranges from russet (R) to chocolate (R) or bay (R), the darker colors being next to the pores. The russet shades may pale toward the crust or the growing margin, and sometimes a narrow zone of clay color (R) occurs just under the crust.

The under surface of some specimens varies between dark olive buff (R) and isabella color (R). These bruise to Verona brown (R). Other specimens vary from light drab (R) to wood brown (R).

Of the twelve collections available for study two are perennial, with two to three layers of pores separated by layers of sterile tissue 3 to 10 millimeters thick, the maximum length of the tubes being 2 centimeters. In longisection (Plate 27, figs. 6 and 7; Plate 31, figs. 8 and 9) the pores vary in color around benzo brown (R) and Natal brown (R).

The pore mouths (Plate 24, figs. 10 to 13; Plate 30, fig. 8) vary from circular to angular, with thin to medium dissepiments, which are entire or somewhat eroded. In size they range from 4.1 to 5.6 to a millimeter, the average for sixty measurements on ten collections being 5.0. Variation in the same specimen may be considerable, however, some pores being two to three times the diameter of the smaller ones.

Ten collections were examined for ratio of pore-wall thickness to diameter of opening. In one hundred measurements the walls varied from 42 to 306 μ and the openings from 167 to 445 μ , the average ratios for the ten being 1 : 1.42, 1 : 1.94, 1 : 1.97, 1 : 2.09, 1 : 2.29, 1 : 2.37, 1 : 2.53, 1 : 2.63, 1 : 2.75, and 1 : 2.86. It is thus seen that, on the average of ten measurements per specimen, the walls are in all cases thinner than the diameter of the pores.

The spores (Plate 36, figs. 7 to 12) are deep to dark olive buff or near old gold, with distinct, usually coarse, striæ. They average 6.33 by 9.66 μ for one hundred twenty measurements from the crushed mounts of ten collections and 6.63 by 10.11 μ for one hundred measurements from the upper surface of seven collections. There is sometimes considerable variability in the same specimen with respect to size. As will be seen from the photomicrograph of the spores of the type (Plate 36, fig. 7) some are comparatively small. Out of forty measurements from the upper surface of the Cuban specimen [2853 (Plate 21, fig. 18)] only five spores were slightly larger than the average for the species, the remainder being appreciably smaller. The age

of the specimen apparently determines the average size, and to some extent the depth of color, but usually a few typical spores are present.

With respect to American species *lobatum* is easy to segregate. Nevertheless, certain specimens of *applanatum* from other parts of the world may have quite similar dark, coarsely striate spores, which would lead to confusion if spore characters alone were used.

SPECIMENS EXAMINED

CUBA, Ceballos, *C. J. Humphrey* 2853.

UNITED STATES, Alabama, Birmingham, Pratt Mine No. 8, *G. M. Hunt* 7007, Tuscaloosa, University campus, on *Quercus nigra*, *C. J. Humphrey* 10583; Arizona, Oracle, on stump of *Quercus emoryi*, *G. G. Hedgcock and W. H. Long* 2364; Florida, Miami, Brickell's Hammock, *C. J. Humphrey* 6983, near Orlando, on seedling orange, *J. R. Winston* 5027; Georgia, Vienna, on *Acer rubrum*, *C. J. Humphrey* 2375; Illinois, Du Quoin, on *Quercus* sp., *C. J. Humphrey* 1343, Metropolis, at base of large living *Morus* sp., *C. J. Humphrey* 9661, on *Quercus* sp., *C. J. Humphrey* 9670; Indiana, Greenwood, *M. C. Jensen* 1202, 6884; Louisiana, near Baton Rouge, *C. J. Humphrey and C. W. Edgerton* 5591, at base of living *Acer rubrum*, *C. J. Humphrey and C. W. Edgerton* 5702, St. Martinsville, *C. J. Humphrey* 4391; Mississippi, Laurel, on *Quercus* sp., *C. J. Humphrey* 5420; North Carolina, *W. C. Coker* 8229, Salem, *ex herb. Schweinitz* 409-90 (type); Texas, Texarkana, *C. J. Humphrey* 13070; Virginia, near Washington, D. C., *W. A. Murrill, ex herb. N. Y. Bot. Gard.*

All the specimens cited are in herb. Humphrey.

MICROSCOPIC FEATURES AS DIFFERENTIAL CHARACTERS

The following synoptic tables (Tables 1 and 2) give the principal microscopical characters of the species and varieties recorded.

In interpreting Table 1 it should be kept in mind that data on the pores and dissepiments are based on a comparatively few specimens selected to show variation, and hence cannot give a true average of the more usual condition. In making the measurements, however, a dissepiment was always paired with the adjoining pore.

It should be noted that the measurements of wall thickness and diameter of pores cannot be correlated with the number of pores per millimeter, for the reason that the former were

TABLE 1.—Measurements of Pores.

Species or variety.	Region.	Specimens examined.		Average number per mm.	Wall thickness range.	Diameter range.	Pores.									
		For pores.	For ratio.				Average ratio thickness to diameter.									
							0 : 0.50	1.01 : 1.50	1.51 : 2.00	2.01 : 2.50	2.51 : 3.00	3.01 : 3.50	3.51 : 4.00	4.01 : 4.50	4.51 : 5.00	5.01 : 6.00
<i>Ganoderma applanatum</i>	United States and Canada.....	16	6	5.3	42-417	139-486	---	1	1	1	3	---	---	---	---	---
Do.....	Austria.....	1	1	4.7	28-167	208-445	---	---	---	---	---	---	1	---	---	---
Do.....	England.....	2	2	4.5	56-306	167-459	---	1	---	---	---	---	---	---	---	---
Do.....	Russia.....	1	1	4.8	28-83	70-167	---	---	1	---	---	---	---	---	---	---
Do.....	Uruguay.....	1	1	5.0	111-167	70-125	---	1	---	---	---	---	---	---	---	---
Do.....	Japan.....	9	3	4.8	70-417	111-417	---	2	---	---	---	1	---	---	---	---
Do.....	China.....	3	2	4.7	56-139	111-167	---	1	1	2	---	---	---	---	---	---
Do.....	Formosa.....	4	3	4.8	56-250	167-486	---	---	---	---	---	---	---	---	---	---
Do.....	Australia.....	6	6	4.8	56-278	83-278	---	1	4	1	---	---	---	---	---	---
Do.....	New Zealand.....	1	1	4.2	42-139	83-139	---	1	---	---	---	---	---	---	---	---
Do.....	Brazil.....	5	5	5.2	70-375	111-306	---	3	1	1	---	---	---	---	---	---
Do.....	Uganda.....	1	1	4.2	28-56	139-236	---	---	---	---	---	---	---	---	---	---
Do.....	Ceylon.....	1	1	4.8	28-70	111-208	---	---	---	---	---	1	---	---	---	---
Do.....	Dutch East Indies.....	2	2	4.5	28-111	97-208	---	---	---	---	---	1	---	---	---	---
Do.....	Philippines.....	7	7	5.2	14-167	70-208	---	---	3	1	---	---	---	1	---	---
Do.....	United States (California).....	7	7	4.3	70-417	139-417	---	2	4	---	---	---	2	---	---	---
<i>G. a. var. brownii</i>	Philippines.....	5	5	5.5	7-70	83-208	---	---	---	---	---	---	2	2	---	---
<i>G. a. var. laetisporum</i>	Philippines; one from Java.....	13	13	5.4	42-348	83-348	1	6	4	2	---	---	---	---	---	---
<i>G. a. var. philippinense</i>	Philippines; one from Africa.....	21	14	5.7	28-348	83-348	1	2	3	2	1	---	---	1	2	---
<i>G. a. var. tornatum</i>	Philippines; one from Africa.....	20	8	5.6	42-167	56-139	---	2	---	---	---	---	---	---	---	---
Do.....	Dutch East Indies.....	3	3	5.6	42-195	56-153	---	1	3	1	---	---	---	---	---	---
Do.....	Federated Malay States.....	5	5	5.8	70-153	83-167	---	---	---	---	---	---	---	---	---	---
Do.....	Australia.....	1	1	5.1	70-348	70-273	2	1	1	---	---	---	---	---	---	---
<i>forma macrospora</i>	Philippines.....	3	3	5.6	56-195	70-273	---	---	---	---	---	---	---	---	---	---
Do.....	Dutch East Indies.....	1	1	5.9	56-167	42-167	1	---	2	---	---	---	---	---	---	---
Do.....	Federated Malay States.....	3	3	5.2	56-111	56-111	---	2	---	---	---	---	---	---	---	---
<i>Ganoderma lobatum</i>	United States; one from Cuba.....	10	10	5.0	42-306	167-445	---	---	1	2	3	4	---	---	---	---

selected here and there to get extremes of variation, while the latter represent more nearly an average for the sporophore.

In *applanatum* the average number per millimeter ranges from 4.2 for a single New Zealand and a single Uganda specimen to 5.3 for United States material, but the remainder fall between 4.5 and 5.2. The range for the United States, however, is 4.5 to 6.7; for Europe 4.5 to 4.8; for Japan 4.0 to 5.7; for China 4.2 to 5.0; for Formosa 4.4 to 5.2; for Australia 4.1 to 5.0; for Brazil 4.8 to 5.8; for the Dutch East Indies 4.2 to 4.8; and for the Philippines 4.5 to 5.8. It is thus seen that the individual ranges overlap to such an extent that pore size is of no value in separating specimens from different countries.

In variety *brownii* the range is from 3.9 to 4.7, which is somewhat under the range for the species.

In variety *laevisporum* the range is from 4.8 to 5.8, with an average somewhat higher than for the species.

Variety *philippinense* also averages somewhat higher than the species, ranging between 4.9 and 6.1, which is within that for United States specimens.

In variety *tornatum*, with the exception of the specimen from Australia, the range also falls within that for United States material of *applanatum*, 4.9 to 6.4, but the average is considerably higher, being 5.7 for the Philippines, 5.6 for the Dutch East Indies, and 5.8 for the Federated Malay States.

In *Ganoderma lobatum* the range is from 4.1 to 5.6 and is, therefore, quite close to *applanatum*.

As far as wall thickness is concerned one may find thin-walled and thick-walled pores in both *applanatum* and its varieties, depending largely on the age of the specimens.

In *applanatum* the average range (averaged from ten selected measurements per specimen) for the United States is from 84 to 241 μ ; for Europe 56 to 229 μ ; for Japan 101 to 272 μ ; for China 84 to 97 μ ; for Formosa 129 to 153 μ ; for Australia 71 to 196 μ ; for Brazil 117 to 267 μ ; for the Dutch East Indies 48 to 59 μ ; and for the Philippines 34 to 88 μ .

In variety *brownii* the corresponding figures are 168 to 260 μ ; it is, therefore, a comparatively thick-walled form.

In variety *laevisporum* they are 25 to 48 μ , this being a very thin-walled form.

Variety *philippinense* runs from 129 to 257 μ .

In variety *tornatum* from the Philippines the average ranges are 56 to 258 μ ; from the Dutch East Indies 53 to 132 μ ; from the Federated Malay States 57 to 143 μ .

In *Ganoderma lobatum* they are 102 to 182 μ .

The only conclusion that the writer can draw is that wall thickness as a specific or varietal character is of no value unless coupled with other characters. The current conception of *tornatum* is that of a thick-walled form, and it is quite true that many of the specimens are so, but one can find just as thick-walled ones in *applanatum* from Brazil and Japan, and even from the United States.

Variation in the diameter of the pores is just as great as in the thickness of the dissepiments. For the United States the average ranges for *applanatum* are 174 to 410 μ (only one at the upper limit, the next highest being 254 μ); for Europe 132 to 388 μ ; for Japan 256 to 338 μ ; for China 140 to 142 μ ; for Formosa 285 to 313 μ ; for Australia 100 to 211 μ ; for Brazil 173 to 225 μ ; for the Dutch East Indies 153 μ ; and for the Philippines 101 to 161 μ .

In variety *brownii* the average ranges are 211 to 353 μ .

In variety *laevisporum* they are 125 to 164 μ .

Variety *philippinense* ranges from 129 to 266 μ .

In variety *tornatum* from the Philippines they are 97 to 268 μ ; from the Dutch East Indies 69 to 108 μ ; from the Federated Malay States 81 to 122 μ .

Ganoderma lobatum pores run from 259 to 355 μ .

In an attempt to interpret the above data on wall thickness and diameter of pores the average was computed for measurements on all the specimens within the regional group. It was found, however, that such data cannot safely be used. As an example, *tornatum* from the Philippines has 5.7 pores per millimeter, based on one hundred twenty measurements from twenty representative specimens. The average for wall thickness was 129 μ and for diameter of pores 210 μ . This would be interpreted as moderately large pores and medium dissepiments, whereas the tendency is toward small pores and rather thick dissepiments. Furthermore, if one should attempt to use the average of the actual measurements on walls and pores and compute on the basis of 5.7 pores to the millimeter the walls alone would occupy 645 μ , leaving only 355 μ for the pores which actually compute 1,080 μ . The total for walls and pores then would be 1,725 μ , an overrun of 72.5 per cent. For Japanese *applanatum* the overrun would be 116 per cent.

In computing the ratio of wall thickness to diameter of pores the total of ten measurements on walls was divided into the

TABLE 2.—Measurements of hyphae and spores (μ).

Species or variety.	Region.	Hyphe.				Spores.	
		Context.		Dissepiments.		Crushed mount.	
		Range.	Average.	Range.	Average.	Average.	Ratio width to length.
<i>Ganoderma appulatum</i>	United States and Canada.....	1.8-9.8	4.5	1.8-6.3	3.9	5.41×8.15	1.51
Do.....	Austria.....	2.2-7.5	4.5	2.2-6.7	4.5	5.2×7.8	1.50
Do.....	England.....	2.2-6.7	4.3	2.2-6.7	3.9	6.1×9.6	1.57
Do.....	Russia.....	2.3-7.2	4.2	2.3-6.0	4.0	6.2×9.2	1.48
Do.....	Uruguay.....	3.0-6.8	4.9	2.7-5.7	3.8	6.5×10.7	1.65
Do.....	Japan.....	1.8-8.2	4.3	2.2-6.0	3.9	5.45×8.35	1.53
Do.....	China.....	2.2-7.5	4.2	2.2-5.7	3.9	5.5×8.3	1.51
Do.....	Formosa.....	2.3-6.8	4.0	2.3-6.0	3.9	6.46×9.56	1.48
Do.....	Australia.....	1.8-7.2	4.1	1.8-6.0	3.4	6.69×10.76	1.61
Do.....	New Zealand.....	2.3-9.0	4.7	2.3-4.5	3.2	6.7×10.4	1.55
Do.....	Brazil.....	2.2-10.4	4.4	2.2-6.3	3.6	6.08×9.72	1.60
Do.....	Uganda.....	2.7-7.5	4.4	2.3-6.0	3.9	6.4×8.5	1.33
Do.....	Ceylon.....	2.3-6.3	4.4	1.8-5.3	3.6	6.3×9.6	1.52
Do.....	Dutch East Indies.....	1.8-7.5	4.0	2.3-6.8	3.8	6.1×8.3	1.36
Do.....	Philippines.....	1.8-9.0	4.3	1.8-8.2	4.1	5.29×8.35	1.58
<i>G. a. var. brownii</i>	United States (California).....	2.2-9.7	5.0	1.5-7.5	3.8	7.60×11.62	1.53
<i>G. a. var. laevisporum</i>	Philippines; one from Java.....	2.2-10.5	4.5	1.5-8.2	3.6	4.97×8.62	1.73
<i>G. a. var. philippinense</i>	Philippines.....	1.2-12.0	4.5	1.5-8.3	3.6	5.43×8.77	1.62
<i>G. a. var. toradum</i>	Philippines; one from Africa.....	1.8-10.4	4.5	1.5-9.0	4.1	5.03×7.58	1.51
Do.....	Dutch East Indies.....	2.3-8.3	4.1	1.8-6.0	3.6	5.16×7.62	1.48
Do.....	Federated Malay States.....	2.3-8.3	4.2	1.5-7.5	3.7	5.97×7.83	1.31
Do.....	Australia.....	1.8-6.8	4.2	1.8-6.0	3.5	6.0×8.3	1.31
Do.....	Philippines.....	1.8-10.5	4.6	1.8-7.5	4.0	5.81×9.36	1.61
Do.....	Dutch East Indies.....	1.8-7.5	4.0	2.3-6.0	3.6	6.05×9.39	1.55
Do.....	Federated Malay States.....	2.3-6.8	4.2	2.3-6.0	3.9	5.63×9.62	1.71
<i>Ganoderma lobatum</i>	United States; one from Cuba.....	2.2-10.5	4.7	1.5-9.0	4.1	6.33×9.66	1.53

Species or variety.	Region.	Spores.					
		Crushed mount.		Upper surface.			
		Range.		Average.	Ratio width to length.	Range.	
		Length.	Width.			Length.	Width.
<i>Ganoderma applanatum</i>	United States and Canada.....	6.3-10.8	4.5-7.5	6.35 × 9.15	1.44	7.8-10.5	5.3-7.5
Do.....	Austria.....	6.7-9.0	4.5-6.0				
Do.....	England.....	8.2-11.2	4.5-7.5				
Do.....	Russia.....	8.3-10.2	5.7-6.8				
Do.....	Uruguay.....	9.8-11.7	6.0-7.5				
Do.....	Japan.....	6.0-10.4	4.5-6.7	6.3 × 9.5	1.51	8.7-10.2	5.7-6.8
Do.....	China.....	7.5-9.0	4.8-6.0				
Do.....	Formosa.....	8.7-10.5	5.7-7.8	6.30 × 9.35	1.48	9.0-9.8	6.0-6.8
Do.....	Australia.....	9.0-12.0	4.8-7.8	6.98 × 11.07	1.59	8.7-12.3	5.7-7.8
Do.....	New Zealand.....	9.8-10.8	6.0-7.2	6.9 × 10.7	1.55	9.8-11.3	6.0-7.2
Do.....	Brazil.....	7.5-11.9	4.5-7.5	6.89 × 10.38	1.51	7.5-12.0	6.0-8.3
Do.....	Uganda.....	7.5-9.0	5.7-7.5	6.1 × 8.9	1.46	6.8-11.3	5.9-7.2
Do.....	Ceylon.....	9.3-10.5	6.0-6.8				
Do.....	Dutch East Indies.....	7.5-9.0	5.7-6.3				
Do.....	Philippines.....	6.0-11.2	4.2-6.7	6.4 × 10.2	1.59	9.0-12.0	5.7-7.2
<i>G. a. var. brownii</i>	United States (California).....	9.7-13.5	6.0-10.5	7.92 × 12.46	1.57	11.3-13.5	7.5-8.3
<i>G. a. var. laetisporum</i>	Philippines; one from Java.....	6.7-10.4	4.5-5.7	5.69 × 8.92	1.55	8.3-10.2	5.3-6.3
<i>G. a. var. philippinense</i>	Philippines.....	7.5-10.4	4.5-7.5	6.16 × 9.45	1.53	9.0-11.3	6.0-7.5
<i>G. a. var. tornatum</i>	Philippines; one from Africa.....	6.0-10.5	4.2-6.7	5.44 × 7.83	1.44	6.7-10.5	4.8-6.3
Do.....	Dutch East Indies.....	6.3-8.7	4.8-6.0	5.68 × 7.93	1.41	7.5-8.7	4.8-6.3
Do.....	Federated Malay States.....	6.8-9.0	4.5-6.8	5.79 × 8.63	1.49	7.8-9.3	5.8-6.3
Do.....	Australia.....	7.5-9.0	5.7-6.3	6.25 × 8.68	1.39	7.8-9.8	5.7-6.8
Do.....	Philippines.....	9.0-11.3	4.8-6.8	6.40 × 10.15	1.59	9.3-11.7	5.7-7.5
Do.....	Dutch East Indies.....	9.0-10.5	5.7-6.8	6.10 × 9.31	1.53	9.0-9.8	5.7-6.3
Do.....	Federated Malay States.....	9.0-10.2	5.3-6.3	5.85 × 9.10	1.56	9.0-9.8	5.7-6.0
<i>Ganoderma lobatum</i>	United States; one from Cuba.....	8.2-11.9	5.2-9.0	6.63 × 10.11	1.52	11.3-13.2	6.8-8.7

total of ten measurements on pores. The individual averages are tabulated to show distribution.

The ratios indicate that for *applanatum* the majority of the collections have pores equal to or up to two and one-half times the thickness of the dissepiments; in variety *brownii* the ratios tend to be somewhat lower, in this respect agreeing with varieties *philippinense* and *tornatum*. *Ganoderma lobatum*, on the other hand, falls more in the category of United States *applanatum*.

Data on the hyphæ and spores include measurements on all the specimens, hence are quite representative of the material reported in the paper and furnish a good average for the larger groups. Unfortunately, however, not enough specimens were available from many of the countries to furnish data sufficient for more than tentative comparisons.

Hyphæ.—Hyphal measurements are of no value as diagnostic characters, averaging throughout the series between 4 and 5 μ for the context and between 3.2 and 4.5 μ for the dissepiments. The larger average for the context hyphæ is due to the inclusion in the context of a few hyphæ of larger dimension than any in the dissepiments.

Spores.—As a rule, the spores taken from the upper surface are larger and darker than those from the context. Also, being frequently more mature, the striæ may be coarser. While we have endeavored to include only apparently mature spores among those measured from the crushed mounts, still the fact that they average smaller than ones from the upper surface indicates that in many instances they have not attained full development. The upper limits are essentially the same, however, whether taken from crushed mount or the upper surface.

Ganoderma applanatum spores run between 9 and 11 μ in length and between 6.8 and 8.3 μ in width.

Variety *brownii* has the largest spores of the group, the upper limits being 13.5 μ for length and 8.3 μ for width.

Variety *philippinense* has spores that are too close to *applanatum* for more than general use as a varietal character, although they have a strong tendency to be paler in color, less coarsely striate and somewhat narrower.

Variety *tornatum*, on the other hand, has very distinctive spores that offer a very good character for varietal segregation. Their upper limits are, as a rule, appreciably under those for *applanatum*. They run usually 7.5 to 8.5 μ long and 4.5 to 5.5 μ

wide, tend to the elliptical, very often lack the truncate or pointed end, and are usually dark and coarsely striate. *Forma macrospora*, however, has the same spores as variety *philippinense*, although averaging slightly larger.

Ganoderma lobatum has spores that occasionally run as large as *brownii*, although the average size is considerably smaller. They are appreciably larger than in *applanatum* from the United States, but are often equaled or surpassed in specimens from other countries, particularly Australia, New Zealand, and Brazil.

Crust.—Photomicrographs of sections through the crust show that the hyphæ take on more or less of a vertical arrangement, small pale ones being intermixed with thicker-walled dark brown ones. Some become clavate at the tips, but no definitely organized palisade layer, resembling basidia, is developed, such as is uniformly found in species of true *Ganoderma*. This is another argument in favor of the segregation of the *Fomes* type of *Ganoderma* into a separate section.

In no instance has there been found any evidence that the club-shaped hyphal endings are conidia-bearing. The spores that accumulate on the upper surface of the sporophores are deposited there by air currents and are purely accidental. Only one representative specimen of each species or variety was sectioned for the crust; therefore, it cannot be stated what differences may exist between young and mature specimens, or what variations may occur in different specimens of the same degree of maturity. The illustrations are introduced largely to show the general structure. We do not believe that such characters can consistently be used in specific or varietal segregation.

Cystida.—Although Patouillard¹⁷⁰ mentions the occasional presence of cystidia in *Ganoderma* and Demelius¹⁷¹ reports them as frequent in *Ganoderma applanatum* and gives a good illus-

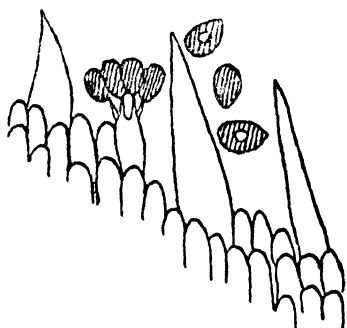


FIG. 1. Hymenium of *Ganoderma applanatum* showing cystidia and spores (after Demelius, pl. 2, fig. 8; enlarged 1.5).

¹⁷⁰ Bull. Soc. Myc. Fr. 5 (1889) 65.

¹⁷¹ Beiträge zur Kenntnis der Cystiden, V, in Verh. k. k. Zool. bot. ges. Wien. 62 (1912) 117.

tration, the writers have not observed them in the comparatively few dry specimens sectioned, for the hymenium was very much disorganized in all. Demelius' figure shows them as sharp-pointed, colorless, thin-walled, fusiform bodies projecting well beyond the basidia. It is herewith reproduced as a matter of record.

SUMMARY AND CONCLUSIONS

The study was carried out in an effort to throw further light on the relationship of the many variations of *Ganoderma applanatum* and closely related species that occur throughout the world, and are particularly prevalent in the Tropics. It is not a monographic treatment, since a number of the species described within the group were not available for examination. It is believed, however, that the system of classification adopted will cover nearly all the temperate-zone variants and that at least 90 per cent of the collections of tropical forms will readily fall within it.

An effort has been made to discuss, to some extent at least, all the described species that pertain to the group. Many of these are obviously nothing but forms and can be dropped from the list of valid species, while others show so many intergrading characters that they are better classed as varieties.

The results presented are based on gross comparisons and critical microscopic examination, particularly of spores and hyphae, of approximately 380 collections from various parts of the world, but more particularly from the Philippines. These specimens include all the material in the Bureau of Science herbarium at Manila, the Baker herbarium at Los Baños, and the herbaria at the Buitenzorg and the Singapore Botanical Gardens, besides a considerable amount of material in the herbarium of the senior author.

In the segregation of variants within the group only two species and four well-marked varieties are recognized; namely, *Ganoderma lobatum* (Schw.) Atk. and *Ganoderma applanatum* (Pers.) Pat., with its varieties *brownii* Murr., *laevisporum* Humph. var. nov., *philippinense* Humph. var. nov., and *tornatum* Pers. The new form *macrospora* Humph. is also erected as an adjunct of *tornatum*. A few other varieties or species have been omitted until authentic material can be examined.

Both gross and microscopic features have been used as characters upon which to base these variants.

Ganoderma applanatum is the common temperate-zone form occurring throughout Europe and the United States, temperate

South America and Africa, temperate Australia, China, Japan, Formosa, and occasionally at the higher altitudes in the Tropics. It shows a rather wide range of variation both in general appearance and spore characters. In the case of forms with thin context the larger spores can be used as a differentiating character to set it off from variety *tornatum*. In the Tropics young forms with rather small spores are occasionally difficult to interpret.

Variety *brownii* results from a reduction of *Elfvigia brownii* Murr. to varietal rank. It is principally based on the large spores, the largest in the group, although the plant tends more to the ungulate than is usual in the base species. Certain forms of *applanatum* from temperate Australia approach the variety quite closely in spore characters but less so in general appearance; in fact, most of the *applanatum* specimens examined from Australia have somewhat larger spores than is usual for the species.

Variety *laevisporum* has been set off largely on account of the wholly nonstriate spores, although the pores are rather small and thin-walled and there are other minor things that serve as "ear marks" rather than as invariable key characters. It has only been reported from the higher altitudes of the Philippines, and once from Java, where it is less typical. It should be remarked, however, that in Japan there are occasional variants of *applanatum* with nonstriate spores; in gross characters some of them are indistinguishable from the base species while others are sufficiently distinct to constitute a separate variety. These need further study from additional collections.

The only other form with nonstriate spores is one having the general appearance of *annulare* Lloyd. Opinion on this is withheld until his type can be studied.

Variety *philippinense* is established principally on gross characters. The upper surface is characteristically tuberculose, there are frequently fawn-colored streaks or bleached areas in the context, and in many specimens the pore surface becomes darkened to mouse gray or blackish slate. It seems to be an analogue of the broadly applanate forms of the base species occurring in the United States, with sufficient variations to set it off as a distinct variety. Bresadola referred many of the specimens to *Ganoderma subtornatum* Murr., while Patouillard frequently used the name *leucophaeum* Mont.

Variety *tornatum* is very distinct in its fully developed and typical condition, and the smaller coarsely striate spores serve

to set it off clearly in most instances. There is, however, a form of it (forma *macrospora* Humph.) which has spores indistinguishable from *applanatum* but sporophores of the same general appearance as *tornatum*. This intermediate form links the base species (*applanatum*) with the variety. Additional evidence of the close relationship exists in the hard, rather small, applanate forms of *applanatum* with moderately thin context that occur in Japan, and occasionally elsewhere.

The name *tornatum* has been selected on account of priority and the existence of the type at Paris. *Ganoderma australe* of Fries is in much dispute. The writer is advised by Miss E. M. Wakefield, of Kew, that the only known Friesian specimen of this species that exists is believed to be at Kew, but it is insect eaten and has lost its outer crust, hence nothing can be established as to the original character of either crust or context. The spores, however, she states, are distinctly larger than in English material. This would preclude the application of the name to the writer's concept of the variety. The presence of rather large spores, however, does not necessarily remove it from *applanatum*, for Australian specimens are predominantly large spored, as is also the single Uruguayan specimen reported. Likewise a comparison of figs. 4 and 5, of Plate 31, will show a wide variation in size of spores from a single English specimen, the larger being quite comparable in size to those of variety *brownii*.

Typical well-developed specimens of *tornatum* are usually applanate, comparatively thin, rather heavy, with comparatively small, thick-walled pores, and a thin context, but many of the smaller specimens are of light weight, with a soft crust and thin-walled larger pores. They even tend to stipitate. These aberrant or young forms have led to much confusion in classification, but they are indubitably connected with the variety by insensible gradations, as shown by forms growing together on the same log.

Ganoderma lobatum is maintained as a distinct species. As compared with United States material it has spores intermediate between *applanatum* and variety *brownii*. The crust is usually soft, thin, and considerably cracked and there is always a distinct rather thick layer of sterile tissue separating the old from the new growth. This has led to the idea that the plant is annual. There is, however, only a gradual dying of the older growth, the newer layers of pores often arising from the old as they do in the "*vegetus*" form of *applanatum*. The general

effect of old perennial sporophores is that the top layers are dead and often insect-eaten with the crust flaked away. This would be very unusual for any other member of the group.

Pore sizes, wall thickness, and size of spores and hyphæ are presented in Tables 1 and 2 so that direct comparison of the averages can be made.

As to number of pores per millimeter the individual ranges overlap to such an extent that they are of no value in separating specimens of *applanatum* from different countries, although *brownii* runs somewhat under the average for the species and *laevisporum* and *philippinense* average somewhat over. The average for *tornatum* is considerably higher.

Pore-wall thickness as a specific or varietal character is of no value unless coupled with other characters. Neither can the ratio of pore-wall thickness to diameter of opening be used safely as a differential character.

Spores offer reasonably good distinguishing characters in varieties *brownii*, *laevisporum*, and *tornatum*. In *Ganoderma lobatum* they are safe enough in comparison with North American material, but unfortunately would cause confusion if used in separating large-spored specimens of *applanatum* from other parts of the world.

Hyphal measurements are of no value within the group.

Sections of the crust show that the hyphæ take on a more or less vertical arrangement, small pale hyphæ being intermixed with thicker-walled dark brown ones. Some become clavate at the tips, but no definitely organized palisade layer, resembling basidia, is developed, such as one uniformly finds in species of true *Ganoderma*. No evidence has been found that the crust is conidia-bearing.

The comparatively few specimens sectioned showed no cystidia, such as were figured by Demelius, but this is probably due to the disorganization of the hymenium.

The study leads to the general conclusion that *Ganoderma applanatum* and its near relatives form an intergrading aggregate which is difficult to split on any invariable character or characters. The best that can be done is to set off certain of the larger groups as varieties with an "ensemble" of group characters; retaining only *applanatum* and *lobatum* as species. *Tornatum* is apparently the strongest variety and might be worthy of subspecific rank if the senior author believed in subspecies.

ILLUSTRATIONS

PLATE 1

GANODERMA APPLANATUM (PERS.) PAT. UNITED STATES

- FIG. 1. Section of 2348 (H), Washington. This type of sporophore with bleached context and pores is very common on *Tsuga heterophylla* in the Pacific northwest; $\times 0.30$.
2. Upper surface of specimen designated "C" in herb. Humphrey, Wisconsin. This is a very common form and represents *G. leucophaeum* of Montagne; $\times 0.29$.
3. Section of "C" shown in fig. 2; $\times 0.29$.
4. Upper surface of a stipitate specimen designated "B" in herb. Humphrey, Wisconsin; $\times 0.25$.
5. Section of "B" shown in fig. 4; $\times 0.25$.
6. Section of a form with thin context, 1369 (H), Illinois; $\times 0.32$.
7. Under surface of a specimen from Wisconsin showing the facility with which it can be etched.
8. Upper surface of 2344 (H), Iowa; $\times 0.32$.
9. Section of 2344 shown in fig. 8. Note the concentric color zones; $\times 0.32$.
10. Large specimen growing on a hard maple log in the forests of the upper peninsula of Michigan.
11. A small atypical pileate specimen taken from mine props of *Acer saccharum* at Ironwood, Michigan.
12. One of the many digitate forms which the fungus assumes when growing in the dark. This plant is about 15 inches long and came from a hard maple mine prop at Ironwood, Michigan. It was associated with the pileate form shown in fig. 11.
13. Section of an unusual-shaped sporophore having a very thin context such as is common in variety *tornatum*. Specimen from the New York State College of Agriculture, Syracuse, in herb. Baker; $\times 0.33$.
14. Section of an English specimen from the Kew Herbarium, at the Bureau of Science; $\times 0.32$.
15. Upper surface of 11537 (H), Japan. This form has nonstriate spores and will probably prove worthy of varietal distinction after a thorough study of Japanese forms has been made; $\times 0.36$.
16. Section of 11537 (H) shown in fig. 15; $\times 0.32$.

PLATE 2

GANODERMA APPLANATUM (PERS.) PAT.

- FIG. 1. Section of 782 (B. S.), from the Botanical Museum, Montevideo, Uruguay. Typical of the temperate zone; $\times 0.36$.
2. Upper surface of 11617 (H), Japan. The upper surface is silvery and the context pale; $\times 0.45$.

- FIG. 3. Section of *11617* shown in fig. 2; $\times 0.45$.
4. Section of *12583* (H), Japan. Compare with Brazilian specimen shown in Plate 4, fig. 5; $\times 0.45$.
5. Upper surface of *11623* (H), Hongkong, China. This specimen matches certain of those from the Philippines; $\times 0.45$.
6. Section of *11623* shown in fig. 5; $\times 0.45$.
7. Upper surface of *12589* (H), Japan; $\times 0.45$.
8. Section of *12589* shown in fig. 7; $\times 0.45$.
9. Upper surface of *Hemmi 25* (H), Japan; $\times 0.45$.
10. Upper surface of *12587* (H), Japan; $\times 0.41$.
11. Section of *12587* shown in fig. 10; $\times 0.47$.
12. Upper surface of two specimens, *Sawada 68* (H), Formosa; $\times 0.43$.
13. Upper surface of *Sawada 78* (H), Formosa; $\times 0.44$.

PLATE 3

GANODERMA APPLANATUM (PERS.) PAT.

- FIG. 1. Upper surface of *Cleland 1* (H), South Australia. This form approaches variety *brownii*; $\times 0.37$.
2. Section of *Cleland 1* shown in fig. 1; $\times 0.35$.
3. Upper surface of *Cleland 13* (H), South Australia; $\times 0.45$.
4. Section of *Cleland 13* shown in fig. 3; $\times 0.41$.
5. Upper surface of *Cleland 14* (H), Tasmania; $\times 0.33$.
6. Section of *Cleland 14* shown in fig. 5. This specimen is referable to the base species on its general appearance and spores although it has in the context the fawn-colored streaks of variety *philippinense*; $\times 0.33$.
7. Section of *Cleland 9* (H), Flinders Island, Australia; $\times 0.38$.
8. Upper surface of *Cleland 8* (H), New South Wales, Australia. From the illustration this would be taken for variety *tornatum* on account of its thin context. The spores, however, are those of the base species; $\times 0.33$.
9. Section of *Cleland 8* shown in fig. 8; $\times 0.41$.
10. Upper surface of *Cleland 27* (H), New South Wales. This specimen is very similar to the Brazilian one shown in Plate 4, fig. 4; $\times 0.33$.
11. Section of *Cleland 27* shown in fig. 10; $\times 0.33$.

PLATE 4

GANODERMA APPLANATUM (PERS.) PAT.

- FIG. 1. Upper surface of a short stipitate specimen of *11059* (H), Brazil. Not included in the present paper and probably represents *testaceum* Lév. Added to the illustrations for the purpose of comparison; $\times 0.49$.
2. Small thick specimen of *11059*, which has a very thin context and was attached at the vertex; $\times 0.49$.
3. A small thin specimen of *11059*, which was broadly attached by the upper surface as if growing on the underside of a log; $\times 0.49$.
4. Section of *10754* (H), Brazil; $\times 0.49$.

- FIG. 5. Section of 11058 (H), Brazil. This is a rather hard specimen quite comparable to forms occurring in Japan; $\times 0.50$.
6. Upper surface of an unusual specimen, 11054 (H), Brazil. It is somewhat intermediate between *applanatum* and *lobatum* and would be referred to the latter were the spores typical of that species; $\times 0.47$.
7. Section of 11054 shown in fig. 6. The context is corky; $\times 0.49$.
8. Upper surface of 11056 (H), Brazil. Probably referable to *testaceum* Lév. and not recorded in the present paper; $\times 0.49$.
9. Section of another specimen of 11056 which was attached at the vertex; $\times 0.49$.
10. Section of 11055 (H), Brazil; $\times 0.39$.
11. Upper surface of 4960, herb. Peradeniya, from Ceylon; $\times 0.44$.
12. Section of 4960 shown in fig. 11; $\times 0.42$.
13. Upper surface of a specimen from herb. Peradeniya, Ceylon, sent as *Fomes annularis* Lloyd, "a stratosed form of *Fomes applanatus* Pers.;" $\times 0.54$.
14. Section of the specimen shown in fig. 13; $\times 0.50$.

PLATE 5

GANODERMA APPLANATUM (PERS.) PAT.

- FIG. 1. Upper surface of 2654 (Bg), Sumatra; $\times 0.33$.
2. Section of 2654 shown in fig. 1; $\times 0.30$.
3. Upper surface of 6315 (B. S.), Mountain Province, Luzon, P. I. Specimen whitish above; $\times 0.31$.
4. Section of 6315 shown in fig. 3; $\times 0.31$.
5. Section of 50100 (B. S.), Mountain Province, Luzon, P. I.; $\times 0.32$.
6. Section of large irregular specimen, 16195 (B. S.), Luzon, P. I.; $\times 0.33$.
7. Upper surface of an old blackened specimen, 3289 (B. S.), Luzon, P. I.; $\times 0.28$.
8. A younger light brownish specimen of 3289. Rather atypical but better referable to the base species than elsewhere; $\times 0.32$.
9. Section of 3289 shown in fig. 8; $\times 0.32$.
10. Upper surface of a very unusual specimen which has the spores of the base species, 50099 (B. S.), Mount Isarog, Luzon, P. I.; $\times 0.29$.
11. Lower surface of 50099 shown in fig. 10; $\times 0.33$.
12. Section of 50099 shown in figs. 10 and 11. The pores are severely bleached; $\times 0.35$.
13. Section of 50102 (B. S.), Mount Banahao, Luzon, P. I. Note the bleaching of the pores and context; $\times 0.36$.
14. Section of a young sterile specimen of 50102 with the context nearly wholly bleached; $\times 0.32$.
15. Upper surface of 45860 (B. S.), Luzon, P. I.; $\times 0.31$.
16. Section of 45860 shown in fig. 15; $\times 0.31$.
17. Upper surface of specimen from West Java, 1926 (Bg). Determined by Patouillard as *Ganoderma fasciatum* (Lév.); $\times 0.32$.
18. Section of 1926 shown in fig. 17; $\times 0.32$.

PLATE 6

GANODERMA APPLANATUM (PERS.) PAT. VAR. BROWNII MURR.

- FIG. 1. Side-surface view of 3200 (H), from *Umbellularia californica*, Berkeley, California; $\times 0.36$.
2. Section of 3200 shown in fig. 1; $\times 0.36$.
3. Surface of a young rather thin sporophore of 4575 (H), Berkeley, California; $\times 0.42$.
4. Section of 4575 shown in fig. 3; $\times 0.40$.
5. Section of 5972 (H), from *Quercus agrifolia*, Berkeley, California; $\times 0.39$.
6. Section of an old specimen designated "A" in Humphrey herbarium, Berkeley, California; $\times 0.41$.
7. Section of another old specimen designated "B" in Humphrey herbarium, Berkeley, California; $\times 0.39$.
8. Upper surface of a rather young specimen, 161 (Bg), Java; $\times 0.40$.
9. Section of 161 shown in fig. 8; $\times 0.40$.

PLATE 7

GANODERMA APPLANATUM (PERS.) PAT. VAR. LAEVIPODUM HUMPH.

- FIG. 1. Upper surface of an average-sized specimen, 50084 (B. S.). Type collection from Mount Data, Mountain Province, Luzon, P. I.; $\times 0.38$.
2. Upper surface of the smallest specimen of 50084; $\times 0.39$.
3. Upper surface of the largest specimen of 50084; $\times 0.31$.
4. Lower surface of 50084 shown in fig. 3; $\times 0.32$.
5. Upper surface of a rather thick specimen of 50084; $\times 0.38$.
6. Section of 50084 shown in fig. 5; $\times 0.38$.
7. Upper surface of a somewhat rough specimen of 50084; $\times 0.29$.
8. Section of 50084 shown in fig. 7; $\times 0.39$.
9. Section of a thin sporophore of 50084; $\times 0.39$.
10. Upper surface of the largest specimen of 50085 (B. S.), from Benguet, Mountain Province, Luzon, P. I. Also designated as one of the type collections; $\times 0.31$.
11. Lower surface of 50085 shown in fig. 10; $\times 0.29$.
12. Section of 50085 shown in figs. 10 and 11; $\times 0.38$.
13. A medium-sized sporophore of 50085; $\times 0.31$.
14. Another medium-sized specimen of 50085; $\times 0.31$.
15. Section of 50085 shown in fig. 14; $\times 0.38$.
16. Upper surface of 7637 (B. S.), Mount Apo, Mindanao, P. I.; $\times 0.39$.
17. Section of 7637 shown in fig. 16; $\times 0.39$.
18. Upper surface of 705 (Bg) *pro parte*, West Java; $\times 0.39$.
19. Section of 705 shown in fig. 18; $\times 0.38$.

PLATE 8

GANODERMA APPLANATUM (PERS.) PAT. VAR. PHILIPPINENSE HUMPH.

- FIG. 1. Upper surface of a large specimen from *Shorea guiso*, 50048 (B. S.), Luzon, P. I. This resembles to a considerable extent the illustration accompanying the type description of *G. lionettii* Rolland; $\times 0.10$.

- FIG. 2. Upper surface of 50044 (B. S.), Luzon, P. I. This would be *G. leucophaeum* for Patouillard; $\times 0.35$.
3. Upper surface of 35999 (B. S.), Basilan, P. I. Determined by Lloyd as *Fomes australis* Fr.; $\times 0.35$.
4. Section of 35999 shown in fig. 3; $\times 0.35$.
5. Upper surface of a mature specimen and section of a very young one, 36094 (B. S.), Basilan, P. I. Determined by Lloyd as *Fomes leucophaeus* Mont.; $\times 0.32$.
6. Upper surface of 10556 (B. S.), Polillo, P. I. Determined by Bresadola as *G. subtornatum* Murr. Context typical of variety *philippinense*; $\times 0.31$.
7. Upper surface of a young sporophore, 35998 (B. S.), Basilan, P. I.; $\times 0.31$.
8. Upper surface of a very young thin specimen, 50103 (B. S.), Luzon, P. I.; $\times 0.35$.
9. Section of 50103 shown in fig. 8; $\times 0.35$.
10. Upper surface of a rugose, radially sulcate specimen, 50093 (B. S.), Mindanao, P. I.; $\times 0.24$.
11. Upper surface of a very young specimen without spores, 157 (B. S.), Luzon, P. I. This specimen is not recorded in the present paper since the determination is doubtful. It bears considerable resemblance to young proliferating growth which sometimes occurs at the margin of *G. mastoporum* Lév.; $\times 0.35$.
12. Section of 157 shown in fig. 11; $\times 0.35$.
13. Upper surface of 50079 (B. S.), Mindanao, P. I.; $\times 0.21$.
14. Section of 50079 shown in fig. 13; $\times 0.21$.
15. Upper surface of 714 (B), Luzon, P. I. Determined by Patouillard as *G. leucophaeum* (Mont.); $\times 0.39$.
16. Upper surface of another specimen of 714; $\times 0.39$.

PLATE 9

GANODERMA APPLANATUM (PERS.) PAT. VAR. PHILIPPINENSE HUMPH.

- FIG. 1. Side view of a large specimen of 50094 (B. S.), Luzon, P. I.; $\times 0.19$.
2. Section of 50094 shown in fig. 1. With five layers of pores; $\times 0.16$.
3. Upper surface and section of a typical light-weight specimen, 35865 (B. S.), Panay, P. I. Lower surface whitish; $\times 0.24$.
4. Section of 50092 (B. S.), Mindanao, P. I.; $\times 0.27$.
5. Upper surface of two specimens, 36007 (B. S.), Basilan, P. I. Determined by Lloyd as *Fomes tornatus* Pers., but with typical *philippinense* context and spores; $\times 0.25$.
6. Section of 16634 (B. S.), Luzon, P. I. Determined by Bresadola as *Ganoderma subtornatum* Murr.; $\times 0.21$.
7. Upper surface of 50077 (B. S.), Mindanao, P. I.; $\times 0.32$.
8. Section of 4548 (B. S.), Luzon, P. I.; $\times 0.32$.
9. Upper surface of a very young specimen, 50049 (B. S.), Luzon, P. I.; $\times 0.37$.
10. Upper surface of a small specimen, 18388 (B. S.), Biliran, P. I. Rather silvery above. Determined by Sydow as *G. testaceum* Lév.; $\times 0.35$.

FIG. 11. Section of 18388 shown in fig. 10; $\times 0.35$.

12. A young subungulate sporophore just beginning to form pores, 47960 (B. S.), Luzon, P. I. The surface is somewhat scrupose and slightly moldy; $\times 0.35$.
13. Section of 47960 shown in fig. 12; $\times 0.35$.
14. Upper surface of a broadly sulcate specimen with typical context, 50065 (B. S.), Luzon, P. I. This was included in Mrs. Clemens' collection 4550 along with the black specimen shown in Plate 17, fig. 9. The remainder of the specimens were good variety *tornatum* (cf. Plate 17, figs. 10 and 11); $\times 0.25$.
15. Applanate specimens on a large white lauan log in the forest, 50047 (B. S.), Luzon, P. I. The smaller specimens removed from the same trunk are included to show the contrast between the whitish and dark lower surfaces (cf. also Plate 10, figs. 1 to 7, for detail views of other sporophores from the same trunk).

PLATE 10

GANODERMA APPLANATUM (PERS.) PAT. VAR. PHILIPPINENSE HUMPH.

- FIG. 1. Upper surface of 50047 (B. S.), Luzon, P. I.; $\times 0.32$.
2. Lower surface of 50047 shown in fig. 1; $\times 0.30$.
 3. Side view of a very young specimen of 50047 in which the pores are just beginning to form; $\times 0.33$.
 4. Section of 50047 shown in fig. 3; $\times 0.33$.
 5. Upper surface of a young specimen of 50047 which is concave, pale brown, and rather smooth. This agrees with what Patouillard calls *G. leucophaeum*; $\times 0.33$.
 6. Lower surface of 50047 shown in fig. 5; $\times 0.30$.
 7. Section of a mature specimen of 50047 which is much thickened at the base and approaches the form shown in Plate 13, fig. 4. Upper surface tuberculose; lower surface whitish. Figs. 1 to 7 represent forms all taken from the side of a large white lauan log in the forests of Mount Maquilang and depict four of the commoner forms in the Philippines; $\times 0.31$.
 8. Upper surface of a short stipitate specimen 50051 (B. S.), Luzon, P. I.; $\times 0.17$.
 9. Lower surface of 50051 shown in fig. 8. The darker area is brown; $\times 0.15$.

PLATE 11

GANODERMA APPLANATUM (PERS.) PAT. VAR. PHILIPPINENSE HUMPH.

- FIG. 1. Stipitate specimen which grew from a covered root at the base of a large lauan trunk, 50055 (B. S.), Luzon, P. I.; $\times 0.17$.
2. Section of 50055 shown in fig. 1; $\times 0.20$.
 3. Upper surface of specimen collected at Bentong Pahang, Federated Malay States, by E. J. H. Corner, May, 1930. This plant is the nearest approximation to *Ganoderma gibbosum* Nees which the writer has seen; $\times 0.20$.
 4. Section of the specimen shown in fig. 3; $\times 0.23$.

- FIG. 5. Upper surface of 23225 (S), Federated Malay States; $\times 0.20$.
 6. Lower surface of 23225 shown in fig. 5. Blackish brown (R); $\times 0.20$.
 7. Section of 23225 shown in figs. 5 and 6; $\times 0.20$.
 8. Upper surface of a stipitate specimen, 50041 (B. S.), Mindanao, P. I. Lower surface near to Mars brown; $\times 0.24$.
 9. Upper surface of 23229 (S), Federated Malay States. Lower surface whitish; $\times 0.15$.
 10. Section of 23229 shown in fig. 9; $\times 0.16$.

PLATE 12

ABERRANT FORMS OF *GANODERMA APPLANATUM* (PERS.) PAT. VAR.
 PHILIPPINENSE HUMPH.

- FIG. 1. Upper surface of 50067 (B. S.), Luzon, P. I. This combines the gross characters of *Ganoderma mastoporum* and varieties *philippinense* and *tornatum*. It is quite distinct on account of the thin *tornatum* context; $\times 0.29$.
 2. Upper surface of 50045 (B. S.), Luzon, P. I.; $\times 0.31$.
 3. Section of 50045 shown in fig. 2. The context is much bleached and there is considerable yellowish in the blend of colors; $\times 0.31$.
 4. Upper surface of 50052 (B. S.), Luzon, P. I. Under surface slate colored; upper surface tuberculose. Typical; $\times 0.28$.
 5. Sulcate form of 50052. Upper surface somewhat silvery, banded with light drab; lower surface slate; $\times 0.22$.
 6. Immature ungulate specimens of 50052 in which the pores are just beginning to form; $\times 0.22$.
 7. Section of one of the ungulate sporophores of 50052; $\times 0.31$.
 8. Front view of a young sporophore of 50052. Figs. 4 to 8 represent specimens taken from around the base of a large rotten stub of *Parashorea malaanonan* or on large limbs fallen from the same tree and lying around the base; $\times 0.31$.
 9. Section of 35867 (B. S.), Panay, P. I. Similar to the base species but with the typical context of variety *philippinense*; $\times 0.25$.
 10. Spatulate stipitate specimen with the typical context of *philippinense* but with the pore mouths of *G. mastoporum*, 8665 (Bg), Borneo; $\times 0.33$.
 11. Section of 8665 shown in fig. 10; $\times 0.30$.
 12. Sections of two specimens from Java, 5479 (H). These are close to the base species and were so determined by Dr. E. A. Burt; $\times 0.31$.

PLATE 13

ABERRANT FORMS OF *GANODERMA APPLANATUM* (PERS.) PAT. VAR.
 PHILIPPINENSE HUMPH.

- FIG. 1. Oblique view of 50071 (B. S.), Luzon, P. I. A young, soft, lightweight specimen, whitish beneath; $\times 0.33$.
 2. Upper surface of 50073 (B. S.), Luzon, P. I.; $\times 0.20$.
 3. Lower surface of 50073 shown in fig. 2; $\times 0.20$.

- FIG. 4. Section of 50073 shown in figs. 2 and 3; $\times 0.30$.
 5. Upper surface of 50075 (B. S.), Luzon, P. I.; $\times 0.25$.
 6. Upper surface and section of 47956 (B. S.), Luzon, P. I.; $\times 0.34$.
 7. Upper surface of a laterally stipitate specimen, *Elmer 14255* (B.), Mindanao, P. I.; $\times 0.34$.
 8. Section of *Elmer 14255* shown in fig. 7; $\times 0.33$.
 9. Upper surface of 50056 (B. S.), Mindanao, P. I.; $\times 0.31$.
 10. Lower surface of 50056 shown in fig. 9; $\times 0.32$.
 11. Section of 50056 shown in figs. 9 and 10; $\times 0.34$.
 12. Small young specimen of 50074 (B. S.), Luzon, P. I.; $\times 0.30$.
 13. Section of 50074 shown in fig. 12; $\times 0.32$.
 14. Upper surface of a mature specimen of 50074; $\times 0.30$.
 15. Section of 50074 shown in fig. 14; $\times 0.32$.

PLATE 14

ABERRANT FORMS OF *GANODERMA APPLANATUM* (PERS.) PAT. VAR.
PHILIPPINENSE HUMPH.

- FIG. 1. Upper surface of a very hard heavy sporophore, 50069 (B. S.), Luzon, P. I.; $\times 0.32$.
 2. Lower surface of 50069 shown in fig. 1; $\times 0.31$.
 3. Section of 50069 shown in figs. 1 and 2. The context has a yellowish brown appearance due to the higher percentage of tawny olive and cinnamon brown in the blend of colors; $\times 0.28$.
 4. Upper surface of 50127 (B. S.), Luzon, P. I.; $\times 0.25$.
 5. Section of 36046 (B. S.), Basilan, P. I. Determined by Lloyd as *Fomes oroflavus* Lloyd. This approaches variety *tornatum* forma *macrospora* in context and spores, but has the fawn-colored streaks of *philippinense*; $\times 0.33$.
 6. Section of another specimen of 36046. This has the *philippinense* context, which agrees quite well with that of the specimen shown in fig. 3; $\times 0.33$.
 7. Section of 50070 (B. S.), Luzon, P. I. The context is rather hard, and yellowish brown; $\times 0.29$.
 8. Upper surface of a short-stipitate specimen, 50062 (B. S.) Luzon, P. I. This looks like a giant form of *G. mastoporum*, but the pores are not typical and the context is good *philippinense*. It has a thick, hard, blackish crust; $\times 0.22$.
 9. Lower surface of 50062 shown in fig. 8; $\times 0.22$.

PLATE 15

GANODERMA APPLANATUM (PERS.) PAT. VAR. *TORNATUM* PERS.

- FIG. 1. Upper surface of a broadly applanate specimen, 2050 (B. S.), Amboina; $\times 0.28$.
 2. Lower surface of 2050 shown in fig. 1. The old portion is blackened; the young superimposed growth is buff in color; $\times 0.28$.
 3. Edge of another specimen of 2050 showing the older portion insect-eaten, with a new pileus forming below. This condition is frequent in *G. lobatum* but otherwise is rare; $\times 0.15$.
 4. Section of 2050 shown in figs. 1 and 2; $\times 0.28$.

- FIG. 5. Upper surface of 6092 (B. S.), Samar, P. I.; $\times 0.35$.
 6. Upper surface of 50006 (B. S.), Luzon, P. I.; $\times 0.35$.
 7. Section of 50006 shown in fig. 6; $\times 0.35$.

PLATE 16

GANODERMA APPLANATUM (PERS.) PAT. VAR. TORNATUM PERS.

- FIG. 1. Upper surface of 50015 (B. S.), Luzon, P. I.; $\times 0.28$.
 2. Lower surface of 50015 shown in fig. 1. Yellowish; $\times 0.27$.
 3. Two sections from the same collection, 36130 (B. S.), Mindanao, P. I.; $\times 0.29$.
 4. Upper surface of a somewhat rosetted specimen, 4547 (B. S.), Luzon, P. I.; $\times 0.29$.
 5. Specimen on dead sapling photographed by Dr. O. A. Reinking, August 7, 1919. Probably from Los Baños, P. I.
 6. Upper surface of 4583 (B. S.), Luzon, P. I.; $\times 0.29$.
 7. Section of 4583 shown in fig. 6; $\times 0.28$.
 8. Upper surface of 12161 (H), Mindanao, P. I.; $\times 0.29$.
 9. Section of 12161 shown in fig. 8; $\times 0.29$.
 10. Upper surface of 50016 (B. S.), Luzon, P. I.; $\times 0.23$.
 11. Section of 50016 shown in fig. 10; $\times 0.23$.
 12. Upper surface of a lobed sporophore, 50018 (B. S.), Luzon, P. I.; $\times 0.19$.
 13. Section of 35979 (B. S.), Mindanao, P. I.; $\times 0.17$.
 14. Upper surface of a laterally stipitate specimen, 50022 (B. S.), Palawan, P. I.; $\times 0.24$.
 15. Upper surface of a specimen closely resembling *G. applanatum* 50013 (B. S.), Mindanao, P. I.; $\times 0.29$.

PLATE 17

GANODERMA APPLANATUM (PERS.) PAT. VAR. TORNATUM PERS.,
EXCEPT FIG. 9, WHICH IS VARIETY PHILIPPINENSE.

- FIG. 1. Upper surface of 50031 (B. S.), Luzon, P. I.; $\times 0.15$.
 2. Section of 50031 shown in fig. 1 and section of a thin sporophore from the same collection; $\times 0.23$.
 3. Upper surface of 47929 (B. S.), Palawan, P. I.; $\times 0.29$.
 4. Section of 47929 shown in fig. 3; $\times 0.29$.
 5. Upper surface of another specimen of 47929; $\times 0.29$.
 6. Section of 47929 shown in fig. 5; $\times 0.29$.
 7. Upper surface of a rather thick specimen, 50032 (B. S.), Luzon, P. I.; $\times 0.24$.
 8. Section of 50032 shown in fig. 7. Note the bleached pores; $\times 0.33$.
 9. Upper surface of an old blackened specimen included in 4550 (B. S.), but which is referable to variety *philippinense*. Reported under 50064, Luzon, P. I.; $\times 0.23$.
 10. Upper surface of two specimens, 4550 (B. S.), Luzon, P. I.; $\times 0.29$.
 11. Section of upper specimen of 4550 shown in fig. 10; $\times 0.29$.
 12. Upper surface and section of 50009 (B. S.), Luzon, P. I.; $\times 0.29$.

- FIG. 13. Upper surface of 50036 (B. S.), Luzon, P. I.; $\times 0.29$.
 14. Section of 50036 shown in fig. 13; $\times 0.33$.
 15. Small ungulate sporophore, 50017 (B. S.), Mindanao, P. I.; $\times 0.29$.
 16. Section of 50017 shown in fig. 15; $\times 0.29$.
 17. Upper surface of applanate specimen of 50017; $\times 0.29$.
 18. Upper surface of another applanate specimen of 50017; $\times 0.29$.
 19. Section of 50017 shown in fig. 18; $\times 0.29$.
 20. Section of a thick specimen with bleached pores, 16028 (B. S.), Luzon, P. I. Determined by Lloyd as *Fomes applanatus*; $\times 0.30$.
 21. Section of another thick specimen, 50005 (B. S.), Luzon, P. I.; $\times 0.29$.
 22. Upper surface of a thin proliferating specimen, 50008 (B. S.), P. I.; $\times 0.23$.
 23. Upper surface of two other specimens of 50008; $\times 0.29$.
 24. Section of 14376 (B. S.), Luzon, P. I. Determined by Graff as *Ganoderma applanatum* (Pers.) Bres.; confirmed by Lloyd; $\times 0.29$.
 25. Section of 659 (B.), Luzon, P. I. Determined by Patouillard; $\times 0.30$.
 26. Section of 4461 (B.), Luzon, P. I. Determined by Patouillard; $\times 0.29$.

PLATE 18

GANODERMA APPLANATUM (PERS.) PAT. VAR. TORNATUM PERS.

Various sporophores collected from the log, Mount Maquiling, near Los Baños, P. I. The sections are not reduced as much as the sporophores and are lettered to correspond with the specimens from which derived. *Bu. Sci.* 50028. Upper surfaces $\times 0.32$; sections $\times 0.55$.

PLATE 19

GANODERMA APPLANATUM (PERS.) PAT. VAR. TORNATUM PERS., EXCEPT
FIGS. 9 AND 10, WHICH ARE FORMA MACROSPORA

- FIG. 1. Upper surface of a small sessile and a stipitate sporophore, 3634 (B.), Luzon, P. I. Determined by Lloyd as *Fomes applanatus*; $\times 0.32$.
 2. Upper surface of a stipitate specimen, 50007 (B. S.), Panay, P. I.; $\times 0.35$.
 3. Lower surface of 50007 shown in fig. 2; $\times 0.35$.
 4. Upper surface of a long-stipitate specimen, 50010 (B. S.), P. I.; $\times 0.35$.
 5. Upper surface of five young specimens, 1662 (B.), Luzon, P. I. Determined by Patouillard as *Ganoderma testaceum* Lév.; $\times 0.32$.
 6. Upper surface and section of a single specimen, Togo, Africa (B. S.), from Berlin Museum; $\times 0.35$.
 7. Upper surface of 5537 (Bg), Java. A light-weight plant; $\times 0.28$.
 8. Section of 5537 shown in fig. 7; $\times 0.33$.

- FIG. 9. Upper surface of variety *tornatum* forma *macrospora*, 17808 A (S), Federated Malay States; $\times 0.34$.
10. Section of 17808 A shown in fig. 9; $\times 0.36$.
11. An immature globose specimen with the pores just beginning to develop, 50011 (B. S.), Luzon, P. I.; $\times 0.35$.
12. Section of 50011 shown in fig. 11; $\times 0.35$.
13. Section of young applanate specimen from the same collection, 50011; $\times 0.35$.
14. Upper surface of 5677 (S), Federated Malay States; $\times 0.33$.
15. Section of 5677 shown in fig. 14; $\times 0.36$.
16. Upper surface of 4985 (S), Federated Malay States; $\times 0.28$.
17. Section of 4985 shown in fig. 16; $\times 0.37$.

PLATE 20

GANODERMA APPLANATUM (PERS.) PAT. VAR. TORNATUM PERS. FORMA
MACROSPORA HUMPH.

- FIG. 1. Upper surface of 50089 (B. S.), Luzon, P. I.; $\times 0.34$.
2. Section of 50089 shown in fig. 1; $\times 0.44$.
3. Upper surface of 50088 (B. S.), Luzon, P. I.; $\times 0.32$.
4. Lower surface of 50088 shown in fig. 3; $\times 0.32$.
5. Upper surface of stipitate specimen 6211 (Bg), West Java. Doubtfully referred here; $\times 0.38$.
6. Lower surface of 6211 shown in fig. 5; $\times 0.43$.
7. Upper surface of a stipitate and a sessile specimen, 5819 (Bg), West Java. An aberrant specimen; $\times 0.38$.
8. Section of sessile specimen of 5819 shown in fig. 7; $\times 0.39$.
9. Upper surface of 1619 (Bg), West Java. Determined by Lloyd as *Fomes koningsbergii* Lloyd; $\times 0.38$.
10. Section of 1619 shown in fig. 9; $\times 0.41$.
11. Upper surface of 5497 (Bg), West Java; $\times 0.38$.
12. Section of 5497 shown in fig. 11; $\times 0.39$.

PLATE 21

GANODERMA LOBATUM (SCHW.) ATK.

- FIG. 1. Upper surface of 6884 (H), Indiana; $\times 0.33$.
2. Upper surface of another specimen of 6884; $\times 0.33$.
3. Upper surface of still another specimen of 6884; $\times 0.33$.
4. Section of 6884 shown in fig. 2; $\times 0.35$.
5. Upper surface of 9670 (H), Illinois; $\times 0.35$.
6. Upper surface of 10583 (H), Alabama; $\times 0.35$.
7. Section of 10583 shown in fig. 6; $\times 0.35$.
8. Upper surface of 7007 (H), from mine in Alabama; $\times 0.35$.
9. Section of 7007 shown in fig. 8; $\times 0.35$.
10. Upper surface of 1202 (H), Illinois; $\times 0.35$.
11. Section of 1202 shown in fig. 10; $\times 0.35$.
12. Section of 1343 (H), Illinois; $\times 0.36$.
13. Upper surface of a large sporophore of 6983 (H), Florida; $\times 0.37$.
14. Section of 6983 shown in fig. 13; $\times 0.35$.
15. Upper surface of a smaller sporophore of 6983; $\times 0.35$.
16. Lower surface of 6983 shown in fig. 15; $\times 0.35$.

- FIG. 17. Section of 6983 shown in figs. 15 and 16; $\times 0.35$.
 18. Upper surface of a stipitate specimen, 2853, Cuba; $\times 0.35$.
 19. Section of 2853 shown in fig. 18; $\times 0.33$.

PLATE 22

PORE SURFACES OF *GANODERMA APPLANATUM* (PERS.) PAT.

- FIG. 1. From Iowa, U. S., 2344 (H); $\times 8$.
 2. From Maine, U. S., 962 (B. S.); $\times 20$.
 3. From England, Kew Botanical Garden (B. S.); $\times 8$.
 4. From England, Kew Botanical Garden. Same specimen as shown in fig. 3; $\times 20$.
 5. From Austria, *Kryptogamae exsiccatae* [Vienna], 940 (B. S.); $\times 20$.
 6. From Australia, National Herbarium of New South Wales, 5990 (B); $\times 20$.
 7. From Japan, 12583 (H); $\times 20$.
 8. From Japan, *Hemmi* 25 (H); $\times 20$.
 9. From Hongkong, China, 11623 (H); $\times 20$.
 10. From Formosa, *Sawada* 78 (H). Showing large and small pores side by side in the same specimen; $\times 20$.
 11. From Uganda, Africa, *Maitland* 377 (H); $\times 20$.
 12. From Nova Petropolis, Brazil, 10754 (H); $\times 20$.
 13. From the Philippines, 16195 (B. S.); $\times 20$.

PLATE 23

PORE SURFACES

- FIG. 1. *Ganoderma applanatum* (Pers.) Pat. var. *brownii* Murr. from California, 3200 (H); $\times 20$.
 2. *Ganoderma applanatum* (Pers.) Pat. var. *laevisporum* Humph. from the Mountain Province, Luzon, P. I., 50086 (B. S.); $\times 20$.
 3. Variety *laevisporum* from the Mountain Province, Luzon, P. I., 50085 (B. S.). Specimen from the type collection; $\times 20$.
 4. *Ganoderma applanatum* (Pers.) Pat. var. *philippinense* Humph. from Luzon, P. I., 50045 (B. S.). Pore surface brownish slate color; $\times 8$.
 5. Variety *philippinense* from Luzon, P. I., 50047 (B. S.), with a light-colored pore surface; $\times 20$.
 6. Another specimen of variety *philippinense* from 50047, with a dark brown pore surface; $\times 20$.
 7. Variety *philippinense* from Panay, P. I., 35882 (B. S.), with a light-colored pore surface; $\times 20$.
 8. Variety *philippinense* from Luzon, P. I., 50057 (B. S.), with a brown pore surface; $\times 20$.
 9. Variety *philippinense* from Panay, P. I., 35867 (B. S.), with a light brown pore surface; $\times 20$.
 10. Variety *philippinense* from Mindanao, P. I., 50092 (B. S.), with a light-colored pore surface; $\times 20$.
 11. Variety *philippinense* from Luzon, P. I. 4548 (B. S.), with a light-colored pore surface; $\times 20$.

- FIG. 12. Variety *philippinense* from Luzon, P. I., 50127 (B. S.), with a slate-colored pore surface; $\times 20$.
13. Variety *philippinense* from Mindanao, P. I., 50093 (B. S.), with a brownish slate pore surface; $\times 20$.
14. Variety *philippinense* from Luzon, P. I., 4551 (B. S.), with a dark brown pore surface; $\times 20$.
15. Variety *philippinense* from Luzon, P. I., 50045 (B. S.), with a brownish slate pore surface. Compare fig. 4. The photographs are taken from the same sporophore, but with different methods of illumination. The orifices are funnel-shaped; $\times 20$.
16. Variety *philippinense* from Luzon, P. I., 42075 (B. S.), with a brown pore surface; $\times 20$.
17. Variety *philippinense* from Luzon, P. I., 50103 (B. S.). A very young specimen with light-colored pore surface; $\times 20$.

PLATE 24

PORE SURFACES

- FIG. 1. *Ganoderma applanatum* (Pers.) Pat. var. *tornatum* Pers., 50023 (B. S.), from Palawan, P. I. Pores with very small orifice and thick dissepiments; $\times 20$.
2. Section of the pores of 50023 shown in fig. 1. The pores are larger than those at the surface, which are somewhat closed by an inward growth of mycelium; $\times 20$.
3. Variety *tornatum* Pers., 50002 (B. S.), from Samar, P. I.; $\times 20$.
4. Variety *tornatum* Pers., 1596 (B. S.), from Luzon, P. I.; $\times 20$.
5. Variety *tornatum* Pers., 19236 (B. S.), from Luzon, P. I.; $\times 20$.
6. Variety *tornatum* Pers., from Togo, Africa (B. S.), from Berlin Museum; $\times 20$.
7. Variety *tornatum* Pers., forma *macrospora* Humph., 2048 (B. S.), from Mindanao, P. I.; $\times 20$.
8. Variety *tornatum* Pers., forma *macrospora* Humph., 2048. Section well below the surface showing larger pores as compared with the somewhat occluded ones at the surface shown in fig. 7; $\times 20$.
9. Variety *tornatum* Pers. forma *macrospora* Humph., 20389 (B. S.), from Luzon, P. I.; $\times 20$.
10. *Ganoderma lobatum* (Schw.) Atk., 1343 (H), from Illinois; $\times 8$.
11. *Ganoderma lobatum* (Schw.) Atk., 6884 (H), from Indiana; $\times 8$.
12. *Ganoderma lobatum* (Schw.) Atk., 6884; $\times 20$.
13. *Ganoderma lobatum* (Schw.) Atk., 9670 (H), from Illinois; $\times 20$.

PLATE 25

LONGISECTIONS OF CRUST, CONTEXT, AND PORES; $\times 4$

- FIG. 1. *Ganoderma applanatum* (Pers.) Pat., 2344 (H), from Iowa.
2. *Ganoderma applanatum* (Pers.) Pat., Cleland 27 (H), from New South Wales, Australia.
3. *Ganoderma applanatum* (Pers.) Pat. var. *brownii* Murr. Specimen designated "A" in herb. Humphrey, from California.
4. *Ganoderma applanatum* (Pers.) Pat. var. *tornatum* Pers., from Togo, Africa (B. S.), from Berlin Museum.

- FIG. 5. *Ganoderma applanatum* (Pers.) Pat. 12583 (H), from Japan, showing the harder black streaks.
 6. *Ganoderma lobatum* (Schw.) Atk., 1343 (H), from Illinois, showing abundant harder black streaks at the base of the pileus.
 7. *Ganoderma applanatum* (Pers.) Pat. from England (B. S.), from the Kew Herbarium.

PLATE 26

LONGISECTIONS OF CRUST, CONTEXT, AND PORES OF *GANODERMA APPLANATUM* (PERS.) PAT. VAR. *LAEVISPORUM* HUMPH.; $\times 4$

- FIG. 1. Section of an average-sized specimen of 50085 (B. S.). Type collection from Benguet, Mountain Province, Luzon, P. I.
 2. Section of a medium-sized specimen of 50084 (B. S.), from Mount Data, Mountain Province, Luzon, P. I. Also designated as one of the type collections.
 3. Section of the thickest and largest specimens of 50084.
 4. Section of a thin sporophore of 50084.
 5. Section of the smallest specimen of 50084.
 6. Section of an old sporophore of 50084. Pore layer very much cracked and eroded.

PLATE 27

LONGISECTIONS OF CRUST, CONTEXT, AND PORES

- FIG. 1. *Ganoderma applanatum* (Pers.) Pat. var. *philippinense* Humph., 50092 (B. S.), from Mindanao, P. I.; $\times 4$.
 2. Variety *philippinense* Humph., 36046 (B. S.), from Basilan, P. I.; $\times 4$.
 3. Variety *philippinense* Humph., 50045 (B. S.), from Luzon, P. I.; $\times 4$.
 4. Variety *philippinense* Humph., 50047 (B. S.), from Luzon, P. I. Section at extreme edge of a pore from specimen with dark lower surface; $\times 393$.
 5. Variety *philippinense* Humph., 50047. Section at extreme edge of a pore from a specimen with light-colored lower surface; $\times 393$.
 6. *Ganoderma lobatum* (Schw.) Atk., 6884 (H), from Indiana; $\times 4$.
 7. *Ganoderma lobatum* (Schw.) Atk., 1343 (H), from Illinois; $\times 4$.

PLATE 28

SECTIONS OF CONTEXT; $\times 393$

- FIG. 1. *Ganoderma applanatum* (Pers.) Pat. var. *philippinense* Humph., 50042 (B. S.), from Luzon, P. I. Photomicrograph of section of the edge of a bleached spot in the context showing the larger normal brown hyphae and the fine nearly colorless ones.
 2. Variety *philippinense* Humph., 50042. Section from within another bleached spot.
 3. Variety *philippinense*, 50042. Radial section from the normal brown context.

PLATE 29

PHOTOMICROGRAPHS OF RADIAL SECTIONS OF THE CRUST; $\times 121$

- FIG. 1. *Ganoderma applanatum* (Pers.) Pat., 2348 (H). Specimen with bleached context from *Tsuga heterophylla*, Washington.
2. Variety *brownii* Murr., designated "B" in herb. Humphrey, from California.
3. Variety *laevisporum* Humph., 50085 (B. S.). Type collection from Mountain Province, Luzon, P. I.
4. Variety *philippinense* Humph., 50042 (B. S.), from Luzon, P. I.
5. Variety *tornatum* Pers., 50004 (B. S.), from Palawan, P. I. The crust is quite typical and rather difficult to indent with the thumb nail.
6. Variety *tornatum* Pers., 50028 (B. S.), from Luzon, P. I. Crust rather thin and easily indented.
7. Variety *tornatum* Pers. forma *macrospora* Humph., 50089 (B. S.), from Luzon, P. I. Crust medium thick and difficult to indent.
8. *Ganoderma lobatum* (Schw.) Atk., from North Carolina, herb. Schweinitz 409-90. Type.
9. *Ganoderma lobatum* (Schw.) Atk., 9670 (H), from Illinois.

PLATE 30

PHOTOMICROGRAPHS OF CROSS SECTIONS OF PORES

- FIG. 1. *Ganoderma applanatum* (Pers.) Pat. 2348 (H), from Washington; $\times 121$.
2. Variety *brownii* Murr., designated "B" in herb. Humphrey, from California; $\times 121$.
3. Variety *laevisporum* Humph., 50085 (B. S.). Type collection from Mountain Province, Luzon, P. I.; $\times 121$.
4. Variety *philippinense* Humph., 50042 (B. S.), from Luzon, P. I.; $\times 121$.
5. Variety *tornatum* Pers., 50004 (B. S.), from Palawan, P. I.; $\times 121$.
6. Variety *tornatum* Pers., 2518 (B), from Luzon, P. I.; $\times 180$.
7. Variety *tornatum* Pers. forma *macrospora* Humph., 50089 (B. S.), from Luzon, P. I.; $\times 121$.
8. *Ganoderma lobatum* (Schw.) Atk., 9670 (H), from Illinois; $\times 121$.

PLATE 31

PHOTOMICROGRAPHS OF LONGISECTIONS OF PORES AND CONTEXT; $\times 121$

- FIG. 1. *Ganoderma applanatum* (Pers.) Pat., 2348 (H), from Washington.
2. *Ganoderma applanatum* (Pers.) Pat. 2348 (H). Section of the bleached context showing the fine colorless hyphae.
3. Variety *brownii* Murr., designated "B" in herb. Humphrey, from California.
4. Variety *laevisporum* Humph., 50085 (B. S.), type collection from the Mountain Province, Luzon, P. I.
5. Variety *philippinense* Humph., 50042 (B. S.), from Luzon, P. I.

- FIG. 6. Variety *tornatum*, Pers. 50004 (B. S.), from Palawan, P. I.
 7. Variety *tornatum* Pers. forma *macrospora* Humph., 50089 (B. S.), from Luzon, P. I.
 8. *Ganoderma lobatum* (Schw.) Atk., from North Carolina, herb. Schweinitz 409-90. Type.
 9. *Ganoderma lobatum* (Schw.) Atk., 9670 (H), from Illinois.

PLATE 32

SPORES OF *GANODERMA APPLANATUM* (PERS.) PAT.; $\times 780$.

- FIG. 1. From upper surface of 2348 (H), Washington.
 2. From upper surface of 6083 (H), Oregon.
 3. From crushed pores of 882 (H), Wisconsin.
 4. The usual type of spores from the crushed pores of an English specimen from the Kew Herbarium.
 5. A group of very large darker spores from the crushed pores of the same English specimen as in fig. 4.
 6. From the crushed pores of 12502 (H), Japan.
 7. From the upper surface of 12583 (H), Japan.
 8. From the crushed pores of 11537 (H), Japan.
 9. From the upper surface of *Sawada* 68 (H), Formosa.
 10. From the upper surface of *Cleland* 9 (H), Flinders Island, Australia.
 11. From the upper surface of *Cleland* 1 (H), South Australia.
 12. From the upper surface of *Cleland* 8 (H), New South Wales, Australia.

PLATE 33

SPORES OF *GANODERMA APPLANATUM* (PERS.) PAT. AND VAR. *BROWNII* MURR.; $\times 780$

- FIG. 1. From the crushed pores of *applanatum*, *Cleland* 5 (H), New South Wales, Australia.
 2. From the upper surface of *applanatum*, *Cleland* 11 (H), Queensland, Australia.
 3. From the upper surface of *applanatum*, 10754 (H), Brazil.
 4. From the upper surface of *applanatum*, 11058 (H), Brazil.
 5. From the upper surface of *applanatum*, *Maitland* 377 (H), Uganda, Africa.
 6. From the upper surface of *applanatum*, 32664 (B. S.), Panay, P. I.
 7. From the crushed pores of *applanatum*, 8734 (B. S.), Mountain Province, Luzon, P. I.
 8. From the upper surface of *applanatum*, 50102 (B. S.), Luzon, P. I.
 9. From the upper surface of variety *brownii*, 3199 (H), California.
 10. From the upper surface of variety *brownii*, 3200 (H), California.
 11. From crushed pores of variety *brownii*, Bornmuller, *Pl. exs. canarienses* 1900, 45, Teneriffe, Canary Islands.
 12. From the upper surface of variety *brownii*, 161 (Bg), Java.

PLATE 34

SPORES OF *GANODERMA APPLANATUM* (PERS.) PAT. VAR. *LAEVISPORUM*
HUMPH. AND VAR. *PHILIPPINENSE* HUMPH.; $\times 780$

- FIG. 1. From the upper surface of variety *laevisporum*, 50086 (B. S.), Mountain Province, Luzon, P. I.
2. From the upper surface of variety *laevisporum*, 50084 (B. S.), Mountain Province, Luzon, P. I. Type collection.
3. From the upper surface of variety *philippinense*, 50057 (B. S.), Luzon, P. I.
4. From the upper surface of variety *philippinense*, 4551 (B. S.), Luzon, P. I.
5. From the upper surface of variety *philippinense*, 10556 (B. S.), Polillo, P. I. Determined by Bresadola as *G. subtornatum* Murr.
6. From the crushed pores of variety *philippinense*, 10556.
7. From the upper surface of variety *philippinense*, 2578 (B. S.), Luzon, P. I.
8. From the upper surface of variety *philippinense*, 50070 (B. S.), Luzon, P. I.
9. From the upper surface of variety *philippinense*, 50062 (B. S.), Luzon, P. I.
10. From the upper surface of variety *philippinense*, 35865 (B. S.), Panay, P. I.
11. Young spores from the upper surface of variety *philippinense*, 35865 (B. S.) Cf. fig. 10.
12. From the crushed pores of variety *philippinense*, 23225 (S), Federated Malay States.

PLATE 35

SPORES OF *GANODERMA APPLANATUM* (PERS.) PAT. VAR. *TORNATUM*
PERS.; $\times 780$

- FIG. 1. From the upper surface of *Bur. Sci.* 14376 (B), Luzon, P. I.
2. From the upper surface of 50125 (B. S.), P. I.
3. From the upper surface of 2955 (B), Luzon, P. I.
4. From the upper surface of *Bur. Sci.* 21596 (B), Palawan, P. I.
5. From the upper surface of 3415 (B), Luzon, P. I.
6. From the upper surface of 4550 (B. S.), Luzon, P. I.
7. From the upper surface of 50033 (B. S.), Mindanao, P. I.; $\times 1166$.
8. From the upper surface of 19202 (S), Borneo.
9. From the upper surface of 5537 (Bg), Java.
10. From the crushed pores of 5494 (S), Federated Malay States.
Note the typical pointed young spore that appears somewhat larger. This is quite characteristic of many young spores in this variety.
11. From the upper surface of specimen from Togo, Africa (B. S.), from Berlin Museum.
12. From the upper surface of *Cleland* 6 (H), Queensland, Australia.

PLATE 36

SPORES OF *GANODERMA APPLANATUM* (PERS.) PAT. VAR. *TORNATUM* PERS.
FORMA MACROSPORA HUMPH. AND *GANODERMA LOBATUM* (SCHW.) ATK.; $\times 780$

- FIG. 1. From the upper surface of forma *macrospora*, 50088 (B. S.), Luzon, P. I.
 2. From the upper surface of forma *macrospora* 50089 (B. S.), Luzon, P. I.
 3. From the upper surface of forma *macrospora*, 2048 (B. S.), Mindanao, P. I.
 4. From the upper surface of forma *macrospora*, 17808 A (S), Federated Malay States.
 5. From the upper surface of forma *macrospora*, 5497 (Bg), Java.
 6. From the upper surface of forma *macrospora*, 6211 (Bg), Java.
 7. From the crushed pores of the type specimen of *lobatum* from herb. Schweinitz, 409-90, North Carolina.
 8. From the upper crushed pores of *lobatum*, 7007 (H), Alabama.
 9. From the upper surface of *lobatum*, 6884 (H), Indiana.
 10. From the upper surface of *lobatum*, 6983 (H), Florida.
 11. From the upper surface of *lobatum*, 1343 (H), Illinois.
 12. From the upper surface of *lobatum*, 2375 (H), Georgia.

TEXT FIGURE

- FIG. 1. Hymenium of *Ganoderma applanatum* showing cystidia and spores (after Demelius, pl. 2, fig. 8, enlarged 1.5).

INDEX TO PLATES

- PLATES 1 TO 5. Sporophores of *Ganoderma applanatum*.
 PLATE 6. Sporophores of *Ganoderma applanatum* var. *brownii* Murr.
 PLATE 7. Sporophores of *Ganoderma applanatum* var. *laevisporum*.
 PLATES 8 TO 12. Sporophores of *Ganoderma applanatum* var. *philippinense*.
 PLATES 13 AND 14. Sporophores of aberrant forms of *Ganoderma applanatum* var. *philippinense*.
 PLATES 15 TO 19. Sporophores of *Ganoderma applanatum* var. *tornatum*.
 PLATE 20. Sporophores of *Ganoderma applanatum* var. *tornatum* forma *macrospora*.
 PLATE 21. Sporophores of *Ganoderma lobatum*.
 PLATES 22 TO 24. Pore surfaces, enlarged.
 PLATES 25 TO 27, FIGS. 1 TO 3, 6, 7. Sections of sporophores, enlarged.

PHOTOMICROGRAPHS

- PLATE 27, FIGS. 4 AND 5. Sections at extreme edge of pores of *Ganoderma applanatum* var. *philippinense*.
 PLATE 28. Structure of context of *Ganoderma applanatum* var. *philippinense*.
 PLATE 29. Structure of crust.
 PLATES 30 AND 31. Structure of pores and context.
 PLATES 32 TO 36. Spores.

INDEX TO SPECIMENS FIGURED ON MORE THAN ONE PLATE

GANODERMA APPLANATUM (PERS.) PAT.

UNITED STATES

2344 (H), Iowa; Plate 1, figs. 8 and 9; Plate 22, fig. 1; Plate 25, fig. 1.

2348 (H), Washington; Plate 29, fig. 1; Plate 30, fig. 1; Plate 31, figs. 1 and 2; Plate 32, fig. 1.

ENGLAND

Specimen from the Kew Herbarium (B. S.); Plate 1, fig. 14; Plate 22, figs. 3 and 4; Plate 25, fig. 7; Plate 32, figs. 4 and 5.

JAPAN

Hemmi 25 (H); Plate 2, fig. 9; Plate 22, fig. 8.

11537 (H); Plate 1, figs. 15 and 16; Plate 32, fig. 8.

12583 (H); Plate 2, fig. 14; Plate 22, fig. 7; Plate 25, fig. 5; Plate 32, fig. 7.

CHINA

11623 (H); Plate 2, figs. 5 and 6; Plate 22, fig. 9.

FORMOSA

Sawada 68 (H); Plate 2, fig. 12; Plate 32, fig. 19.

AUSTRALIA

Cleland 1 (H); Plate 3, figs. 1 and 2; Plate 32, fig. 11.

Cleland 8 (H); Plate 3, figs. 8 and 9; Plate 32, fig. 12.

Cleland 9 (H); Plate 3, fig. 7; Plate 32, fig. 10.

Cleland 27 (H); Plate 3, figs. 10 and 11; Plate 25, fig. 2.

BRAZIL

10754 (H); Plate 4, fig. 4; Plate 22, fig. 12; Plate 33, fig. 3.

11058 (H); Plate 4, fig. 5; Plate 33, fig. 4.

UGANDA

Maitland 377 (H); Plate 22, fig. 11; Plate 33, fig. 5.

PHILIPPINES

16195 (B. S.); Plate 5, fig. 6; Plate 22, fig. 13.

50102 (B. S.); Plate 5, figs. 13 and 14; Plate 33, fig. 8.

GANODERMA APPLANATUM (PERS.) PAT. VAR. BROWNII MURR.

UNITED STATES

Collection "A" in herb. Humphrey, California; Plate 6, fig. 6; Plate 25, fig. 3.

Collection "B" in herb. Humphrey, California; Plate 6, fig. 7; Plate 29, fig. 2; Plate 30, fig. 2; Plate 31, fig. 3.

3200 (H), California; Plate 6, figs. 1 and 2; Plate 23, fig. 1; Plate 33, fig. 10.

JAVA

161 (Bg.); Plate 6, figs. 8 and 9; Plate 33, fig. 12.

GANODERMA APPLANATUM (PERS.) PAT. VAR. LAEVISPORUM HUMPH.

PHILIPPINES

50084 (B. S.); Plate 7, figs. 1 to 9; Plate 34, fig. 2.

50085 (B. S.); Plate 7, figs. 10 to 15; Plate 23, fig. 3; Plate 29, fig. 3; Plate 30, fig. 3; Plate 31, fig. 4.

50086 (B. S.); Plate 23, fig. 2; Plate 34, fig. 1.

GANODERMA APPLANATUM (PERS.) PAT. VAR. PHILIPPINENSE HUMPH.

PHILIPPINES

4551 (B. S.); Plate 23, fig. 14; Plate 34, fig. 4.

10556 (B. S.); Plate 8, fig. 6, Plate 34, figs. 5 and 6.

35865 (B. S.); Plate 9, fig. 3; Plate 34, figs. 10 and 11.

35867 (B. S.); Plate 12, fig. 9; Plate 23, fig. 9.

36046 (B. S.); Plate 14, figs. 5 and 6; Plate 27, fig. 2.

50042 (B. S.); Plate 28, figs. 1 to 3; Plate 29, fig. 4; Plate 30, fig. 4; Plate 31, fig. 5.

50045 (B. S.); Plate 12, figs. 2 and 3; Plate 23, figs. 4 and 15; Plate 27, fig. 3.

50047 (B. S.); Plate 9, fig. 15; Plate 10, figs. 1 to 7; Plate 23, figs. 5 and 6; Plate 27, figs. 4 and 5.

50057 (B. S.); Plate 23, fig. 8; Plate 34, fig. 3.

50062 (B. S.); Plate 14, figs. 8 and 9; Plate 34, fig. 9.

50070 (B. S.); Plate 14, fig. 7; Plate 34, fig. 8.

50092 (B. S.); Plate 9, fig. 4; Plate 23, fig. 10; Plate 27, fig. 1.

50093 (B. S.); Plate 8, fig. 10; Plate 23, fig. 13.

50103 (B. S.); Plate 8, figs. 8 and 9; Plate 23, fig. 17.

50127 (B. S.); Plate 14, fig. 4; Plate 23, fig. 12.

FEDERATED MALAY STATES

23225 (S); Plate 11, figs. 5 to 7; Plate 34, fig. 12.

GANODERMA APPLANATUM (PERS.) PAT. VAR. TORNATUM PERS.

PHILIPPINES

4550 (B. S.); Plate 17, figs. 10 and 11; Plate 35, fig. 6.

14376 (B. S.); Plate 17, fig. 24; Plate 35, fig. 1.

50004 (B. S.); Plate 29, fig. 5; Plate 30, fig. 5; Plate 31, fig. 6.

50028 (B. S.); Plate 18; Plate 29, fig. 6.

AFRICA

Specimen from Togo from Berlin Museum (B. S.); Plate 19, fig. 6; Plate 24, fig. 6; Plate 25, fig. 4; Plate 35, fig. 11.

JAVA

5537 (Bg); Plate 19, figs. 7 and 8; Plate 35, fig. 9.

GANODERMA APPLANATUM (PERS.) PAT. VAR. TORNATUM PERS. FORMA
MACROSPORA HUMPH.

PHILIPPINES

2048 (B. S.); Plate 24, figs. 7 and 8; Plate 36, fig. 3.

50088 (B. S.); Plate 20, figs. 3 and 4; Plate 36, fig. 1.

50089 (B. S.); Plate 20, figs. 1 and 2; Plate 29, fig. 7; Plate 30, fig. 7;
Plate 31, fig. 7; Plate 36, fig. 2.

FEDERATED MALAY STATES

17808 A (S); Plate 19, figs. 9 and 10; Plate 36, fig. 4.

JAVA

5497 (Bg); Plate 20, figs. 11 and 12; Plate 36, fig. 5.

6211 (Bg); Plate 20, figs. 5 and 6; Plate 36, fig. 6.

GANODERMA LOBATUM (SCHW.) ATK.

UNITED STATES

409-90, Schweinitz type from North Carolina (H); Plate 29, fig. 8;
Plate 31, fig. 8; Plate 36, fig. 7.

1343 (H), Illinois; Plate 21, fig. 12; Plate 24, fig. 10; Plate 25, fig. 6;
Plate 27, fig. 7; Plate 36, fig. 11.

6884 (H), Indiana; Plate 21, figs. 1 to 4; Plate 24, figs. 11 and 12;
Plate 27, fig. 6; Plate 36, fig. 9.

6983 (H), Florida; Plate 21, figs. 13 to 17; Plate 36, fig. 10.

7007 (H), Alabama; Plate 21, figs. 8 and 9; Plate 36, fig. 8.

9670 (H), Illinois; Plate 21, fig. 5; Plate 24, fig. 13; Plate 29, fig. 9;
Plate 30, fig. 8; Plate 31, fig. 9.

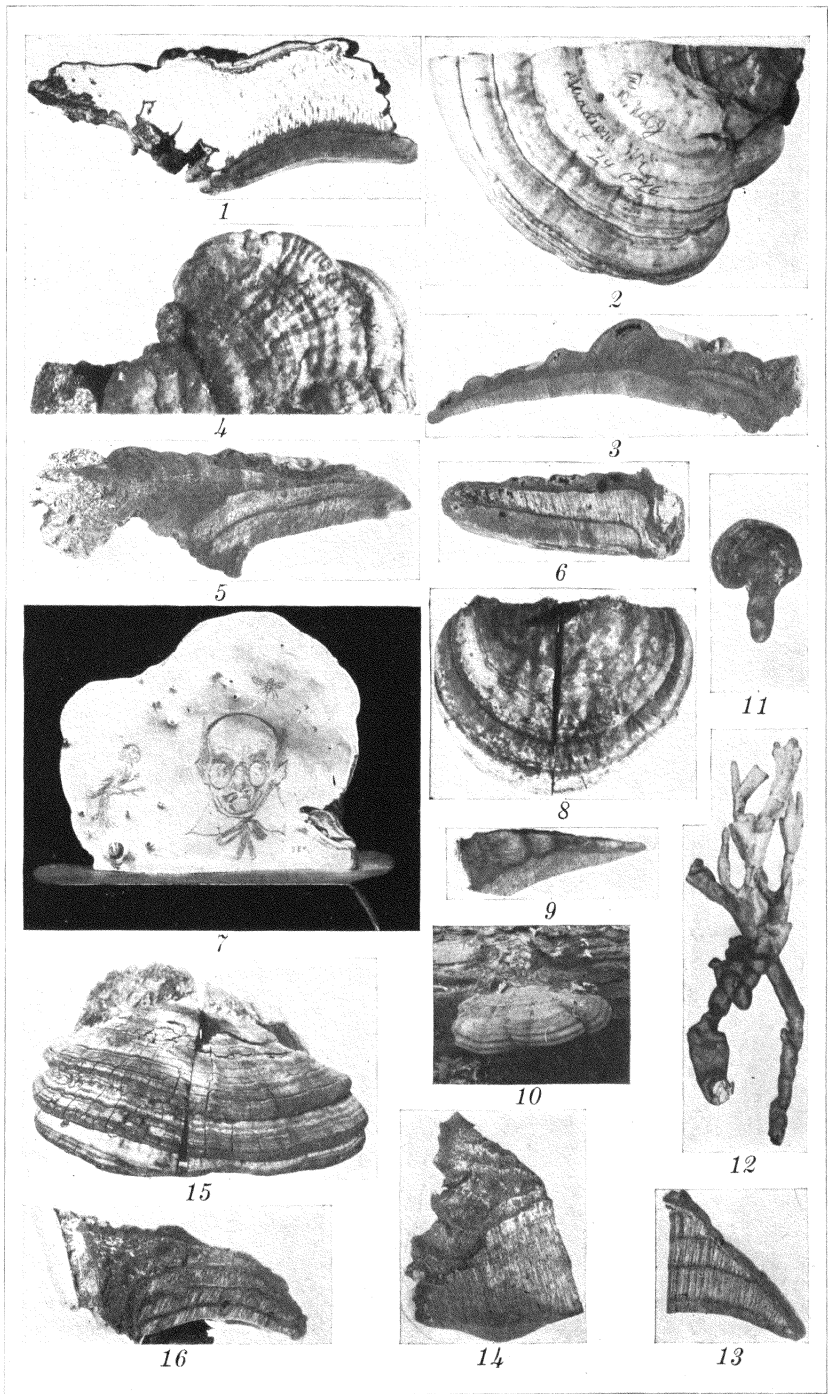


PLATE 1.

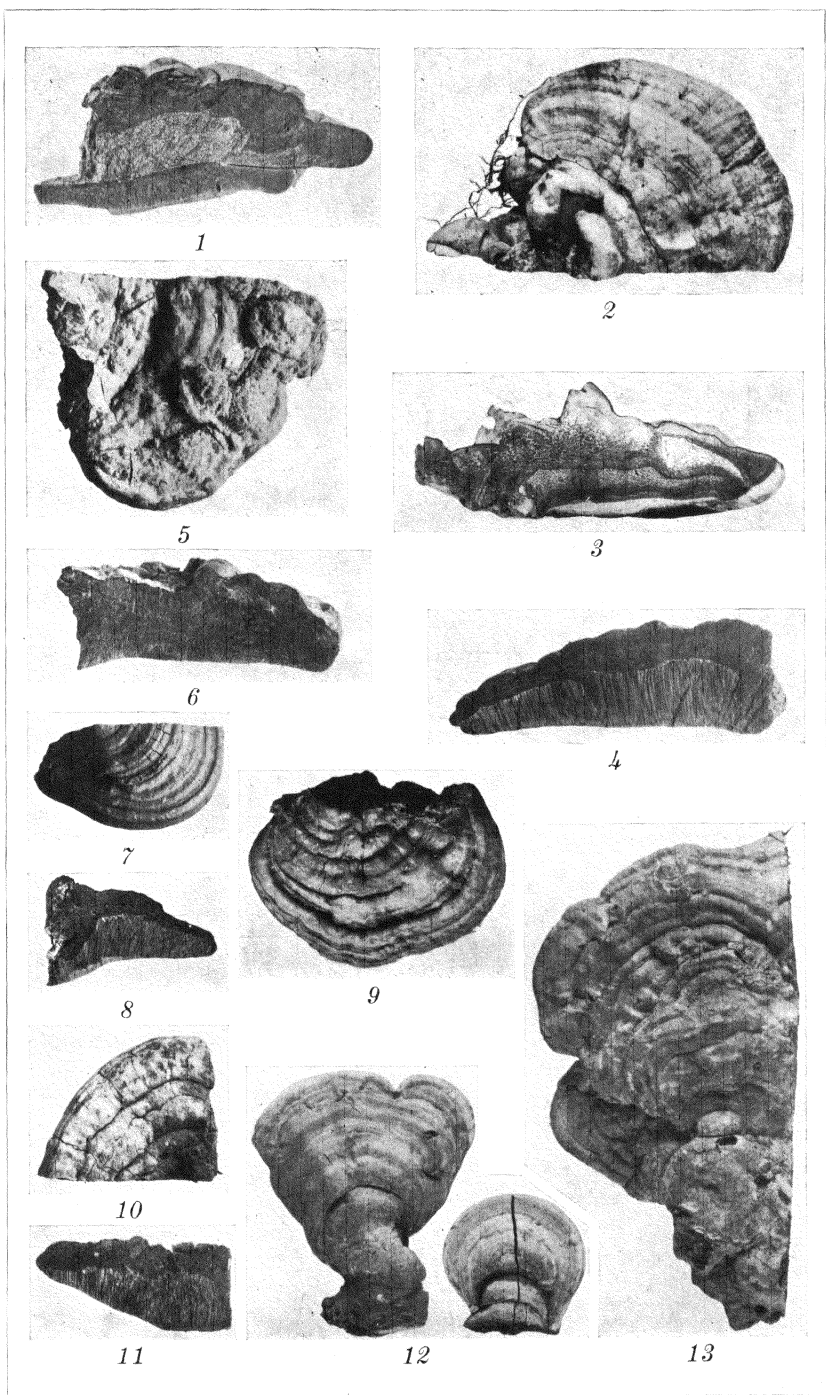
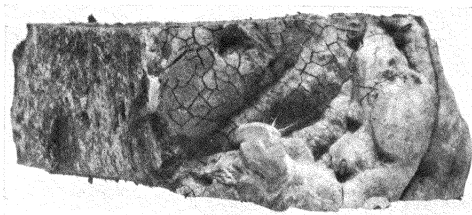
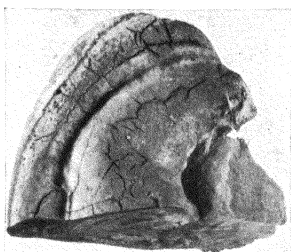


PLATE 2.



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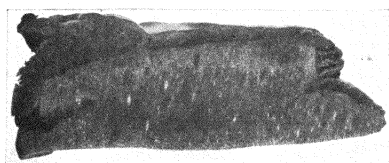
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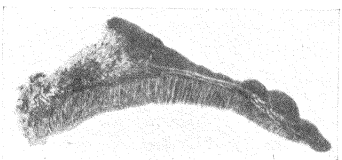
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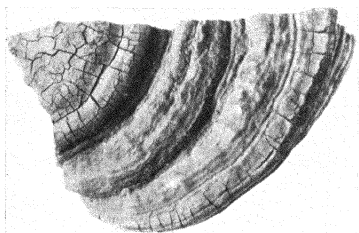
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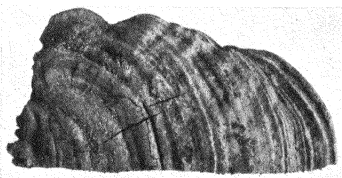
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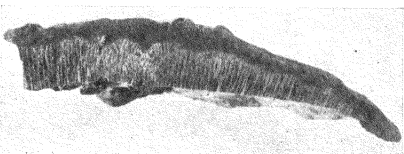
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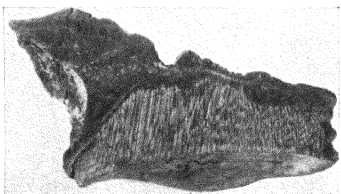
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8



9



11

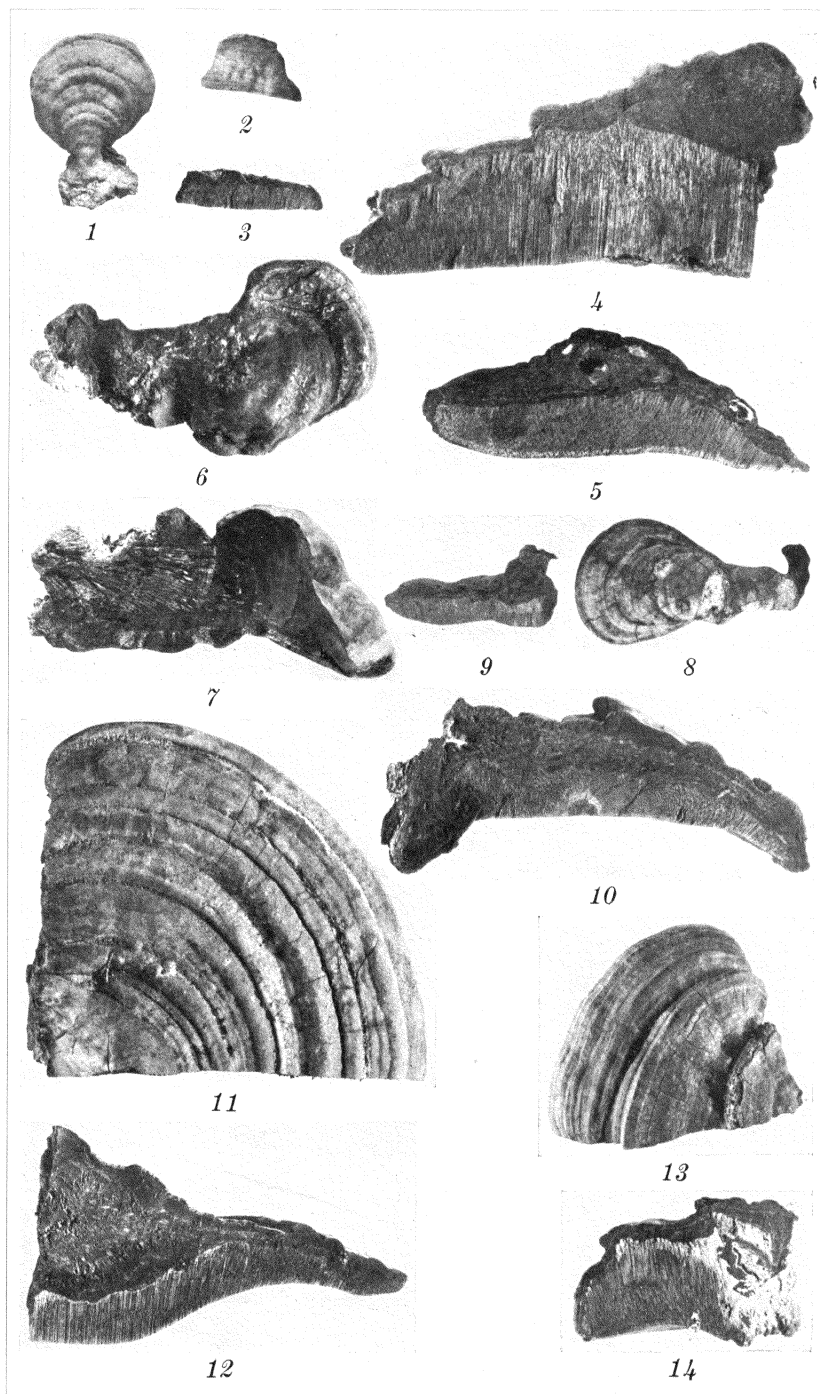


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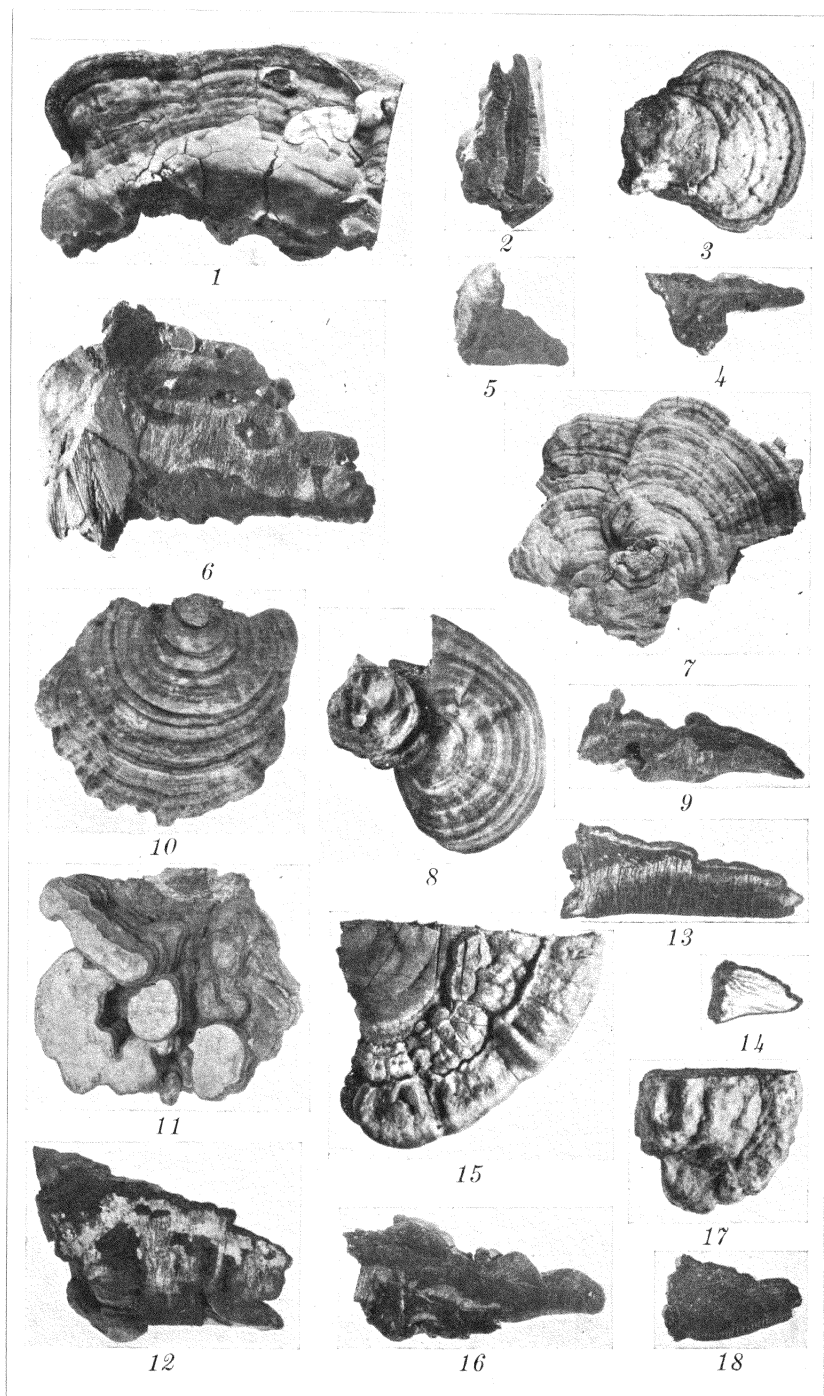
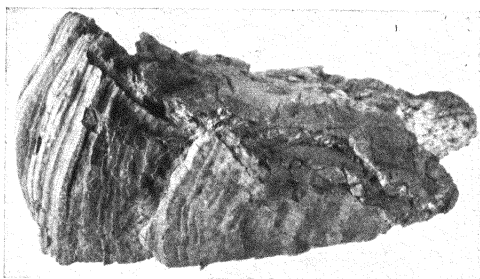


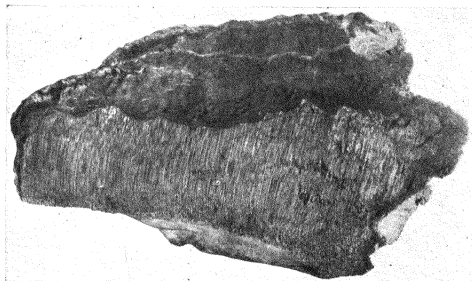
PLATE 5.



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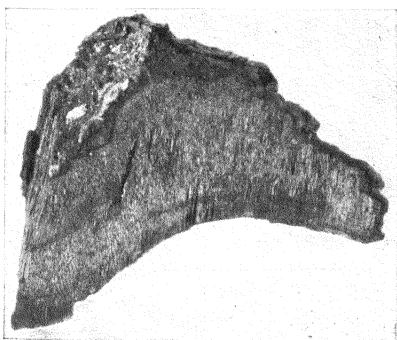
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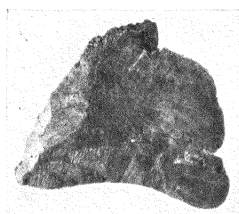
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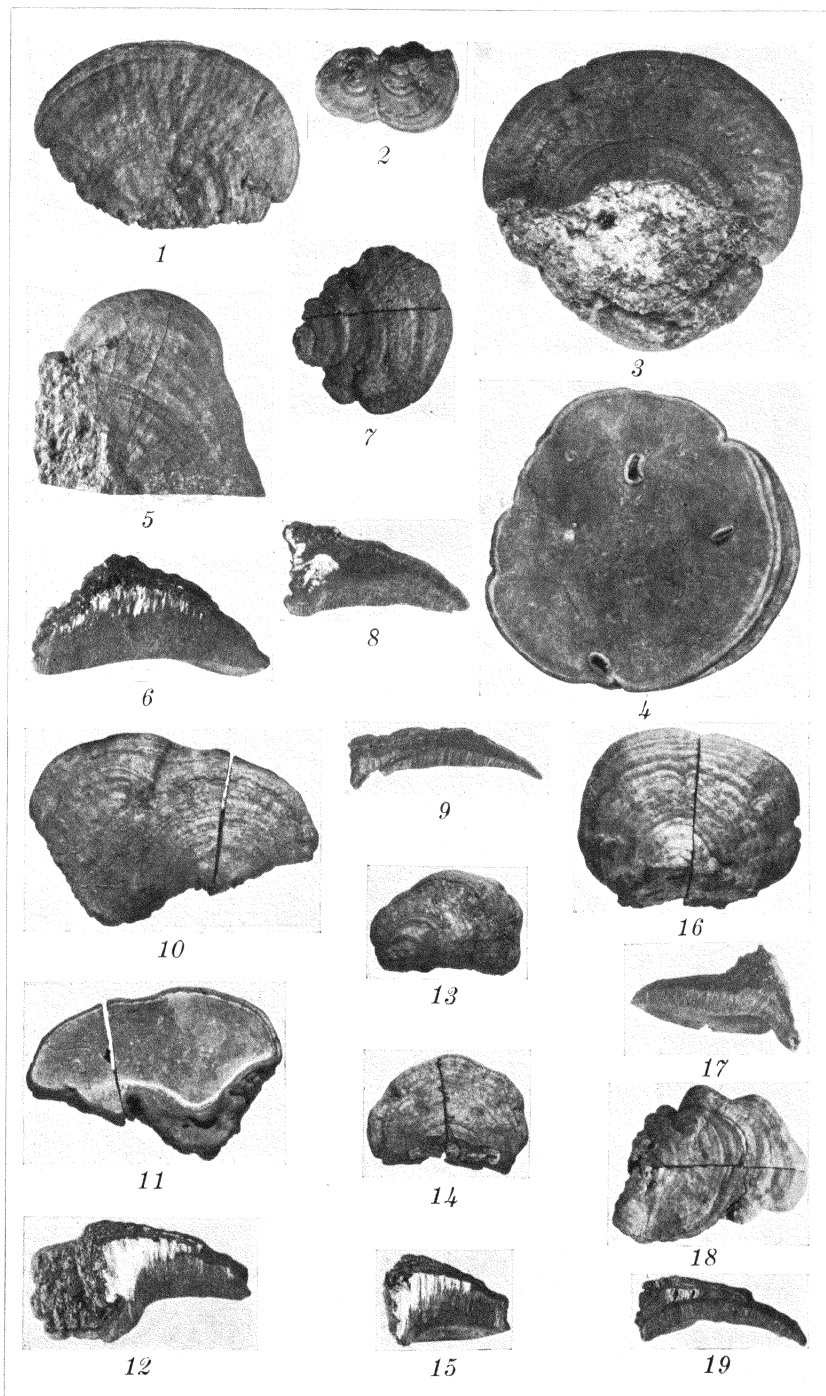


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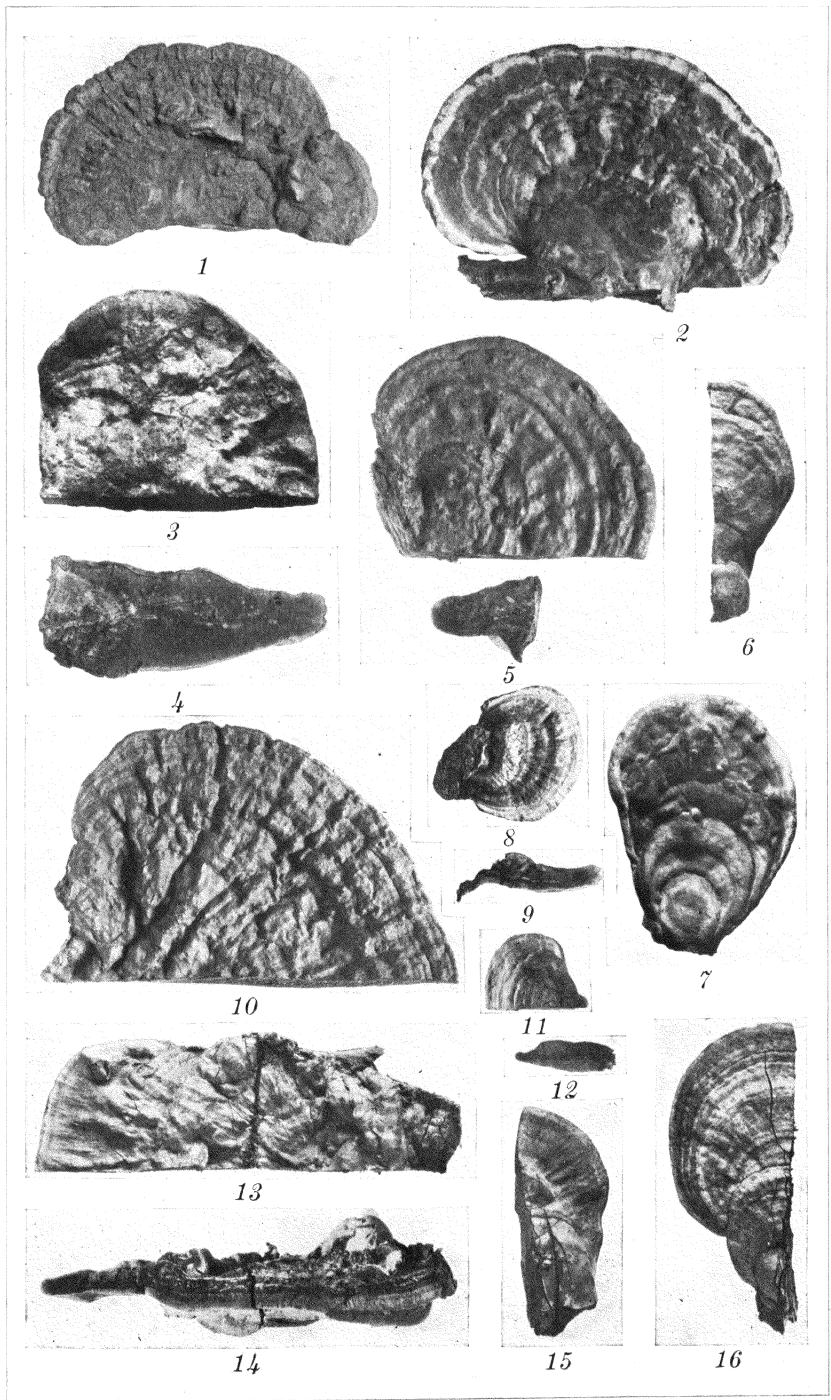


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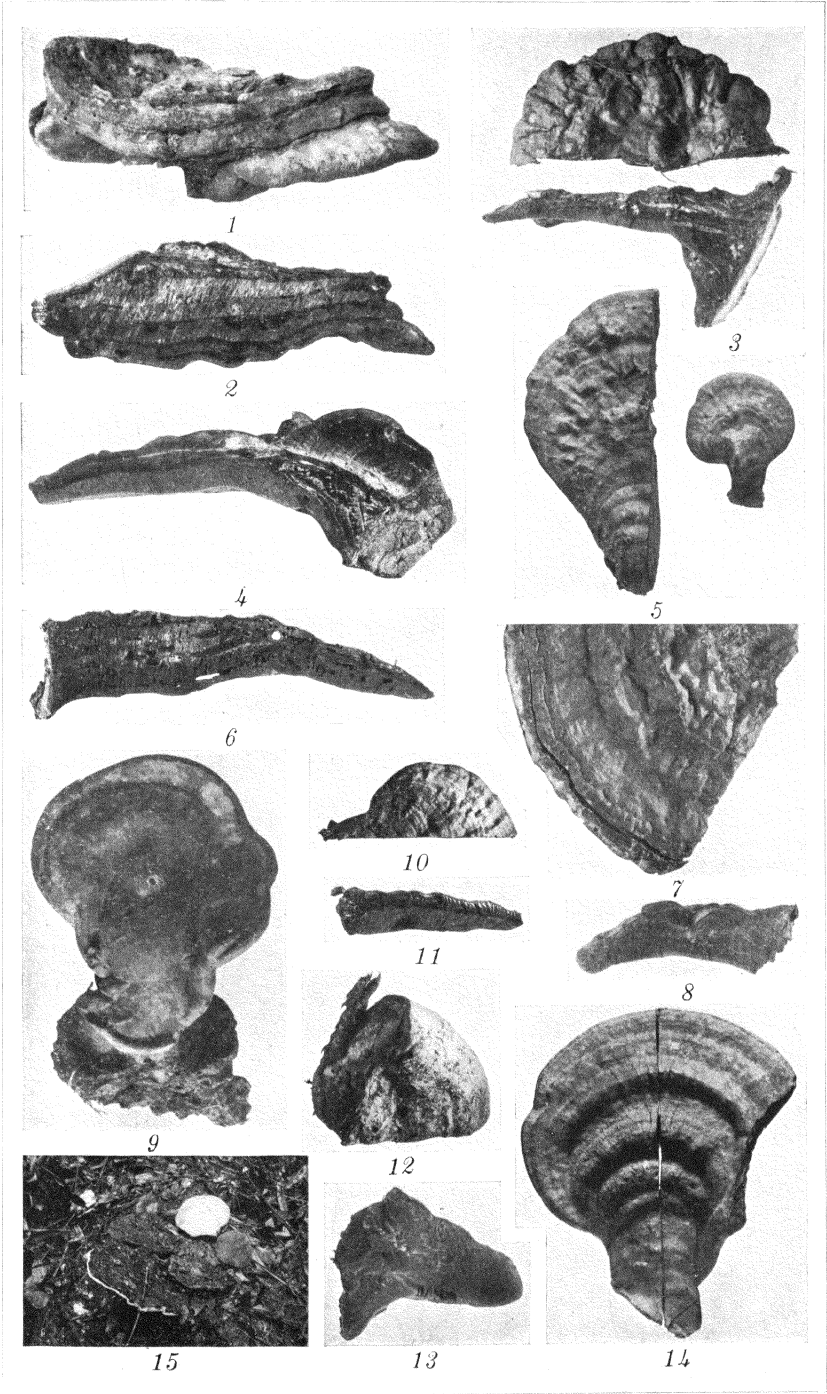


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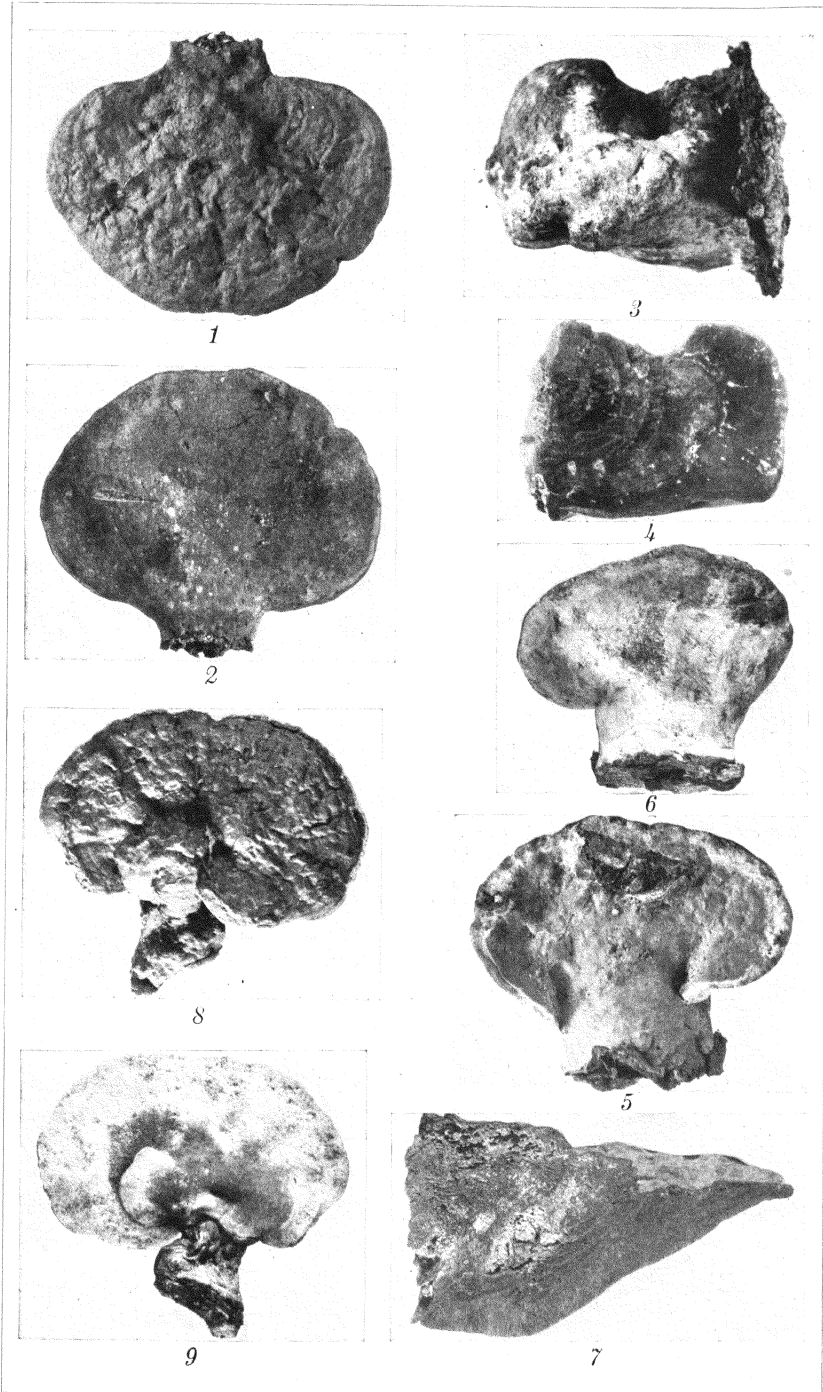
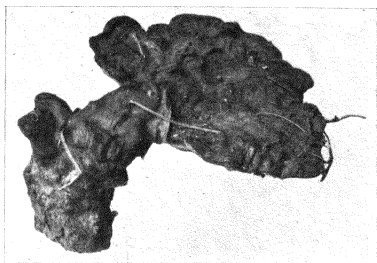
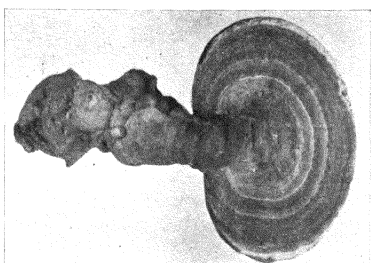


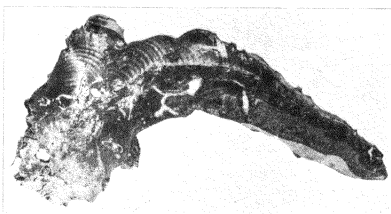
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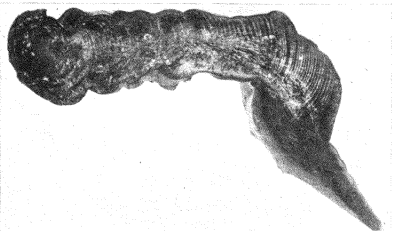
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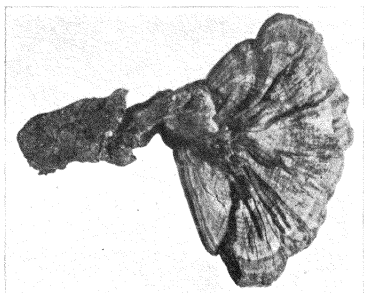
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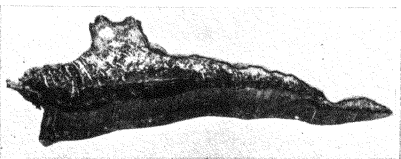
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9



7



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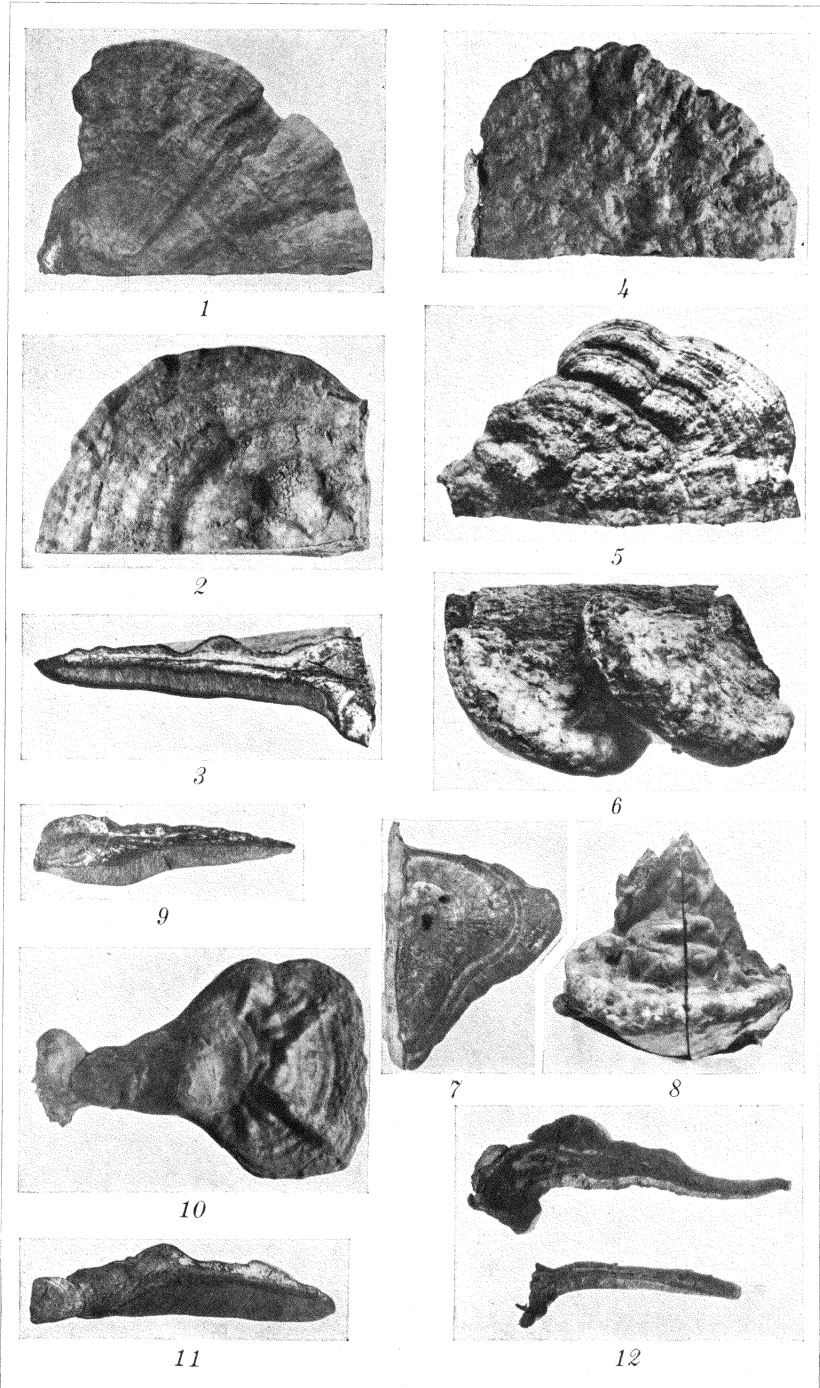


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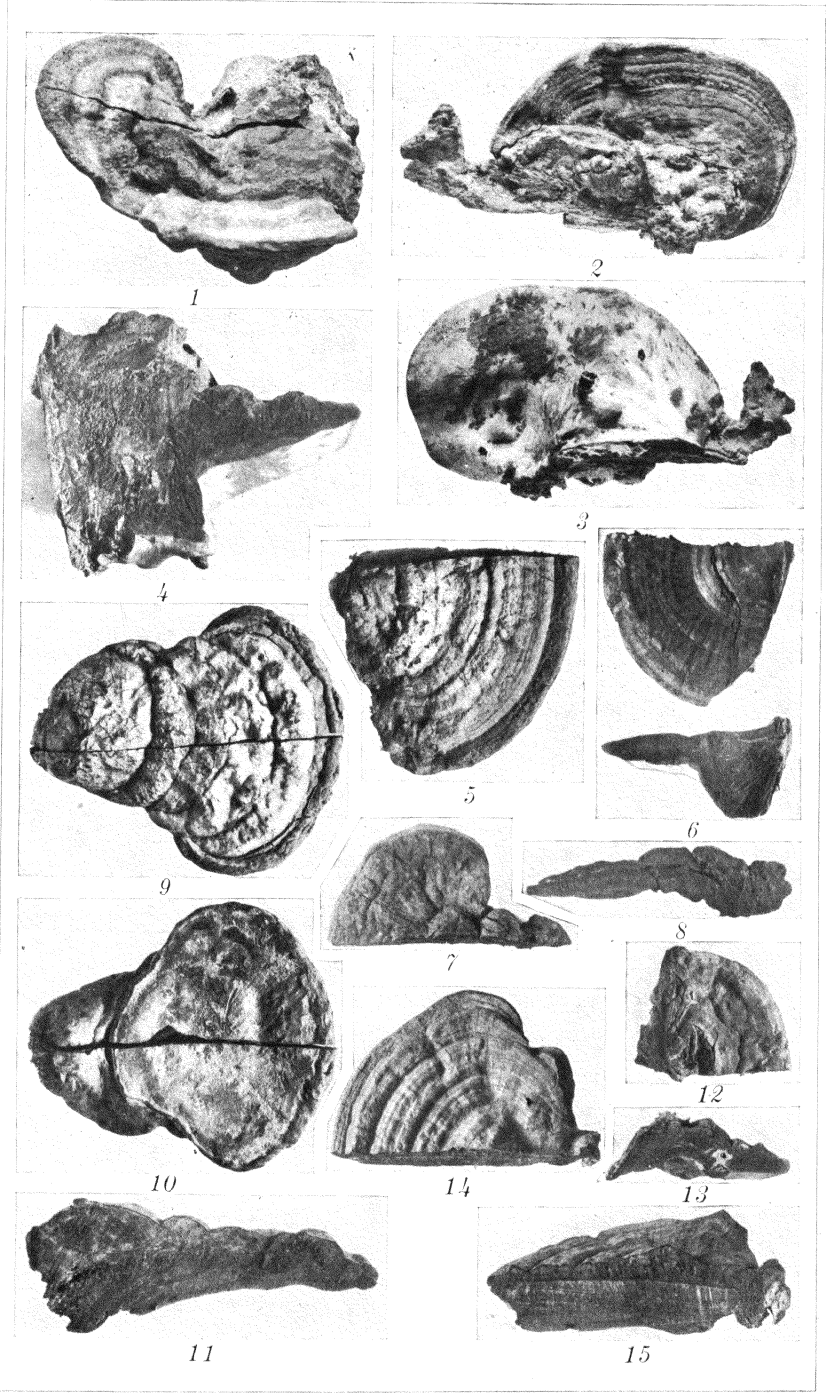


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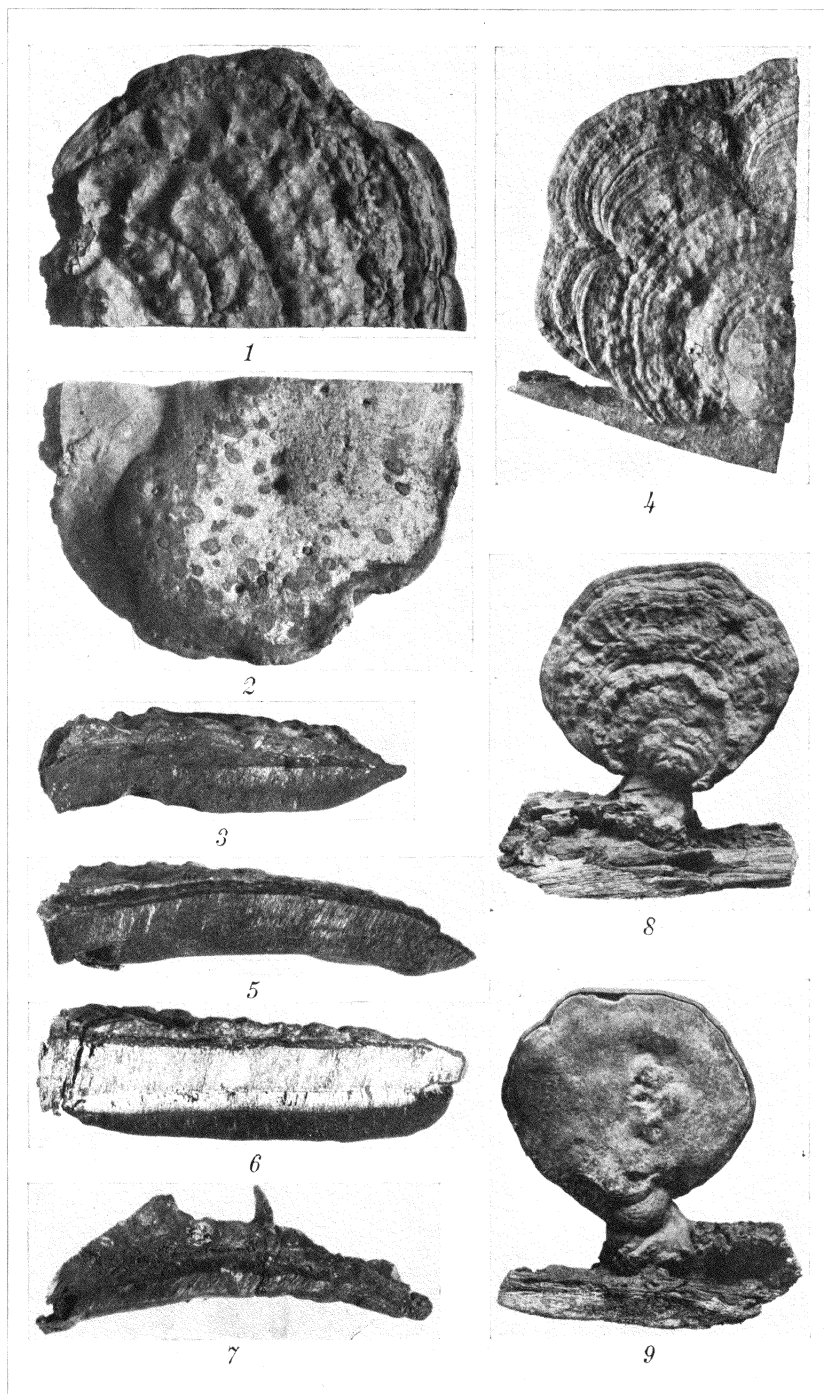


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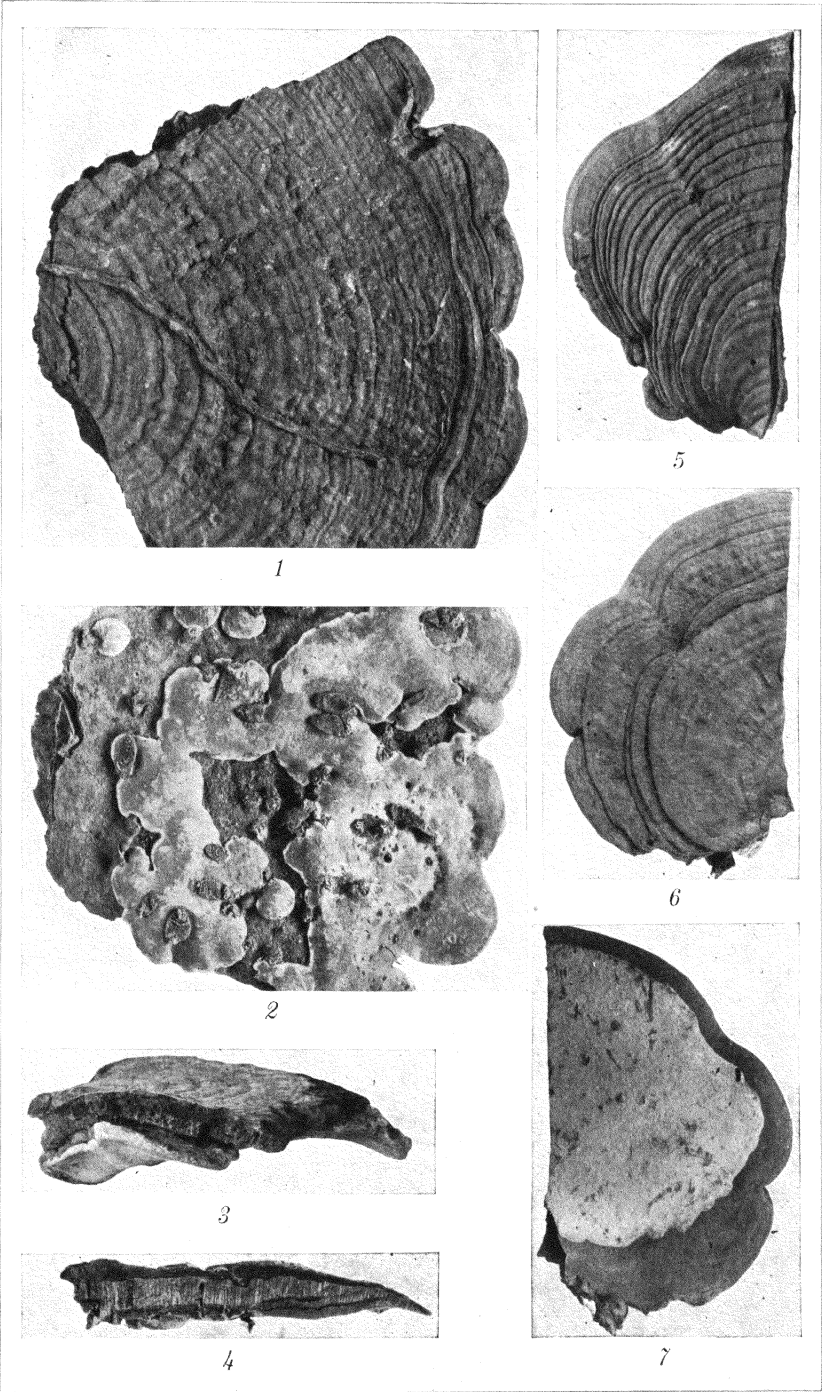


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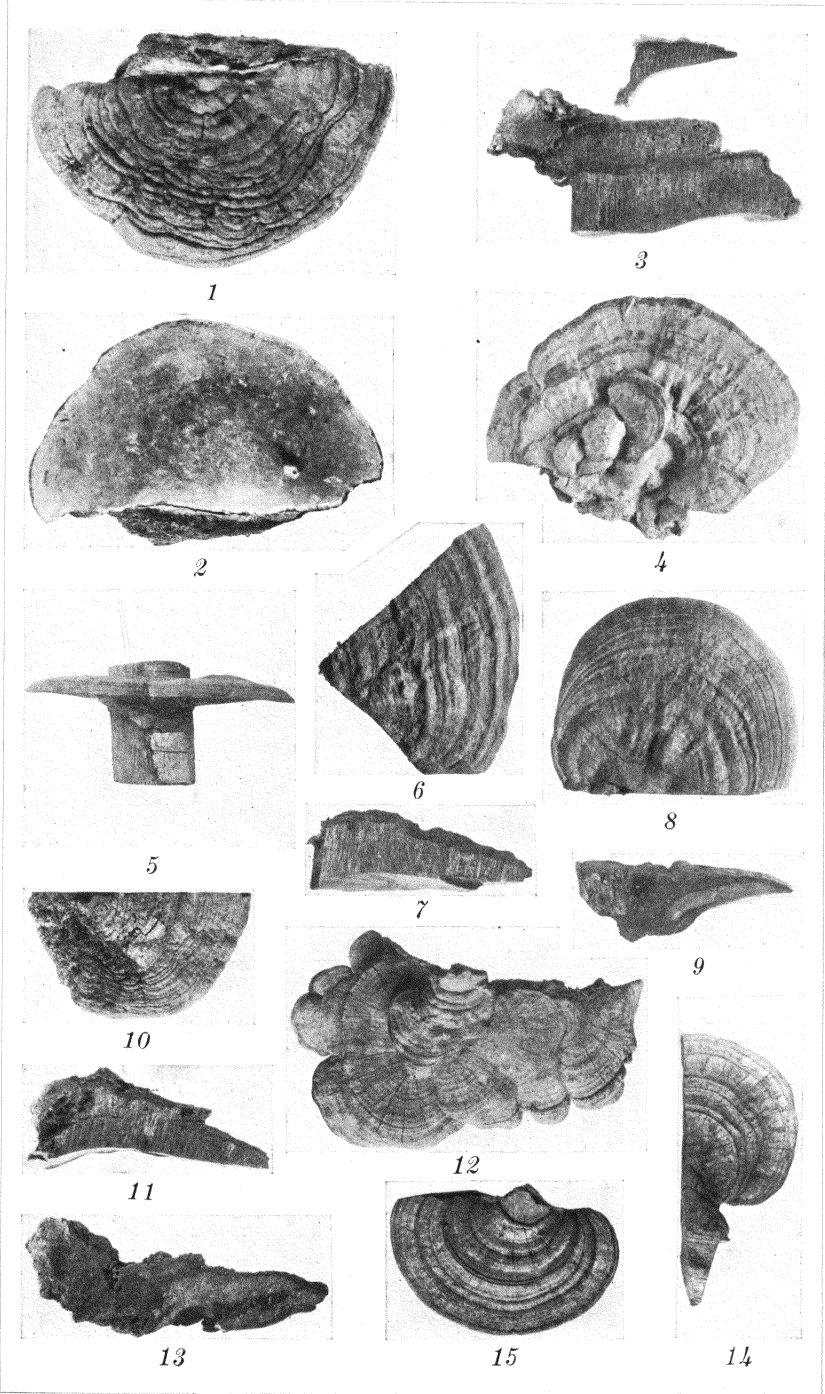


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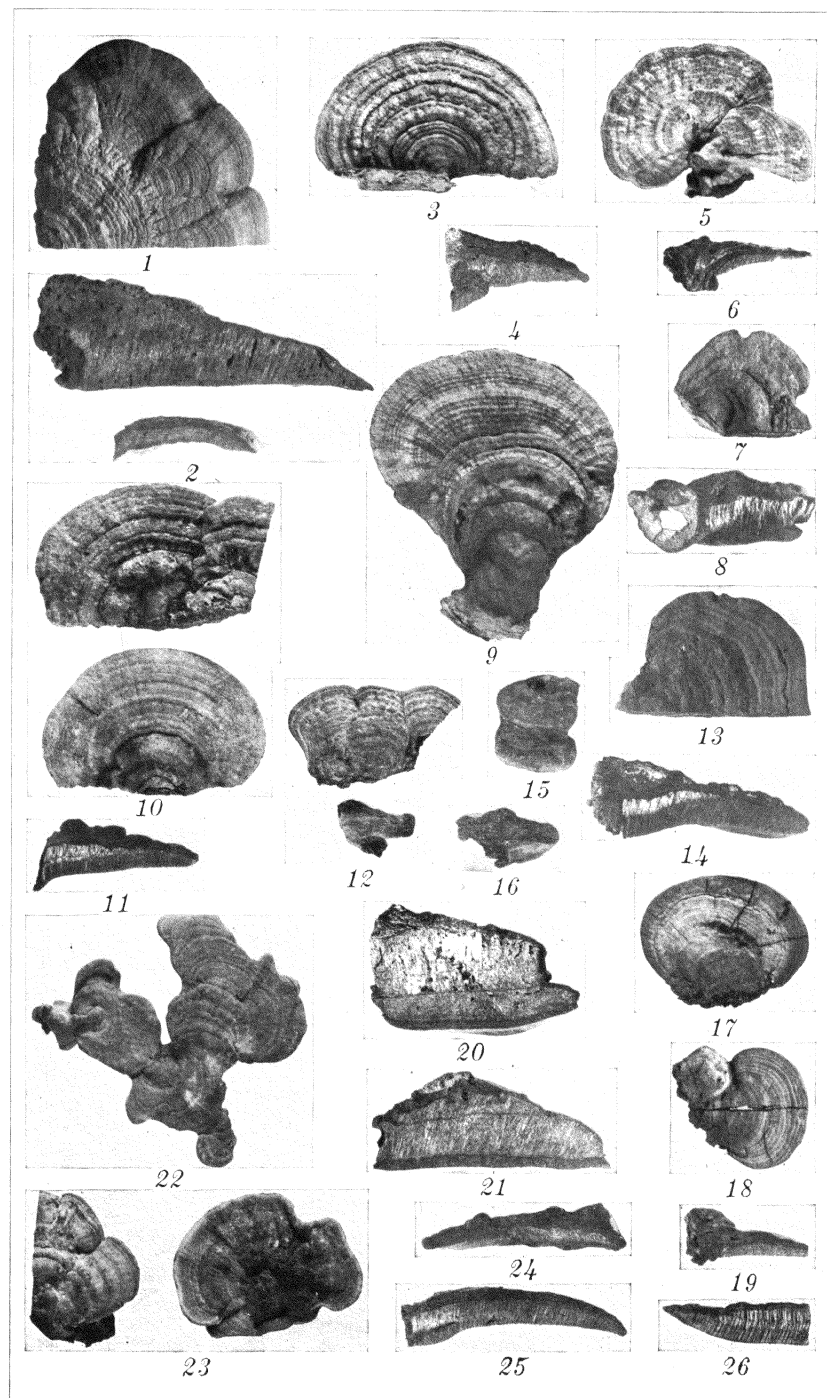


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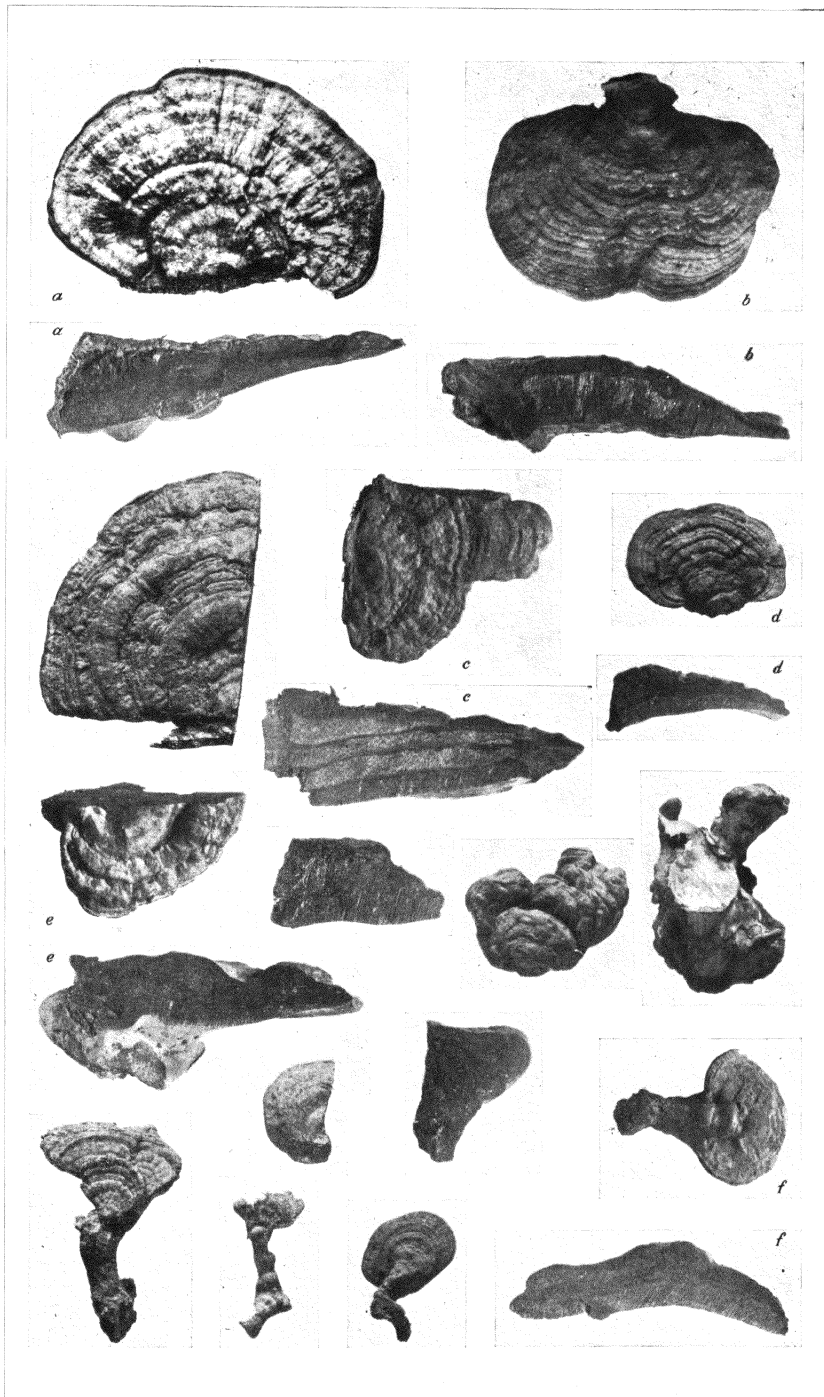


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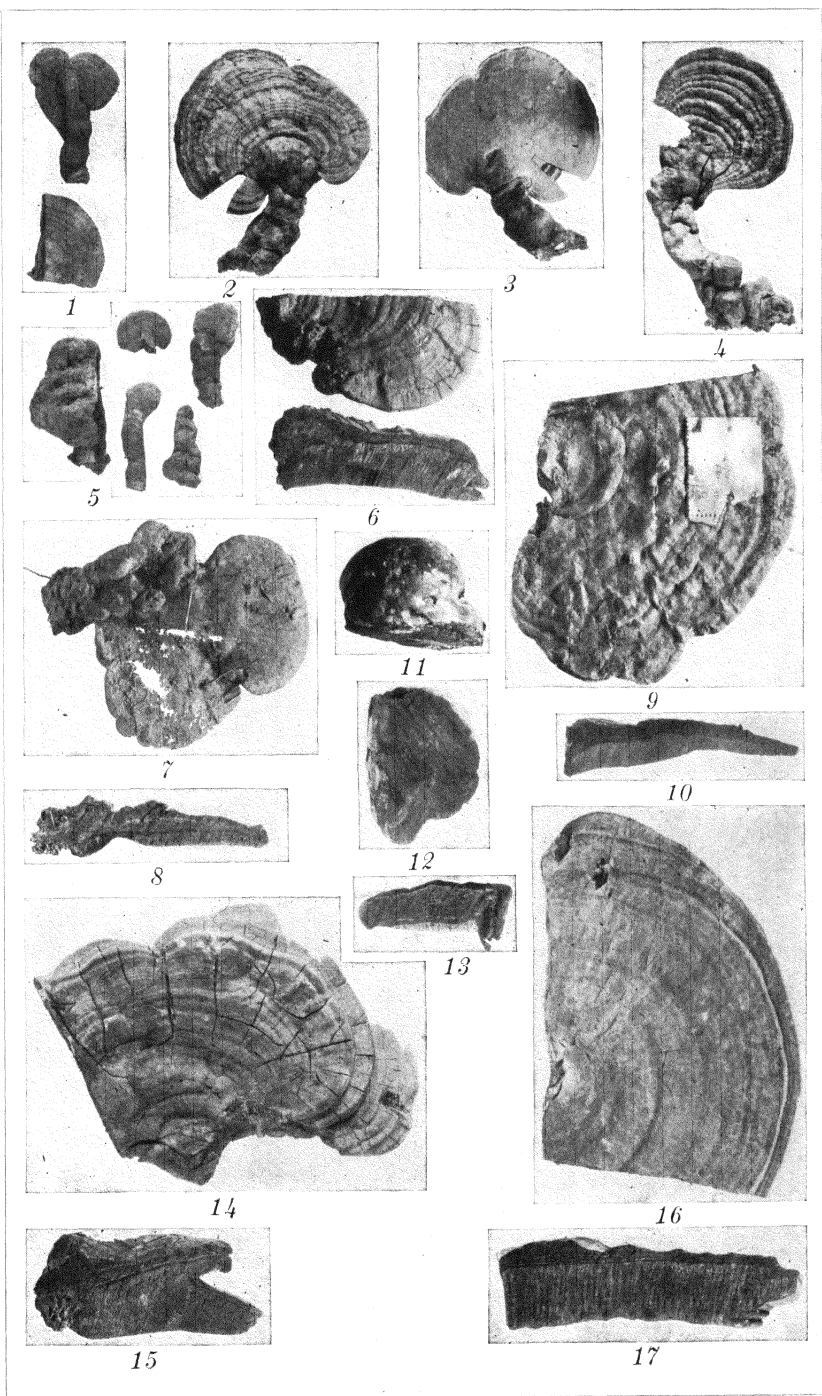


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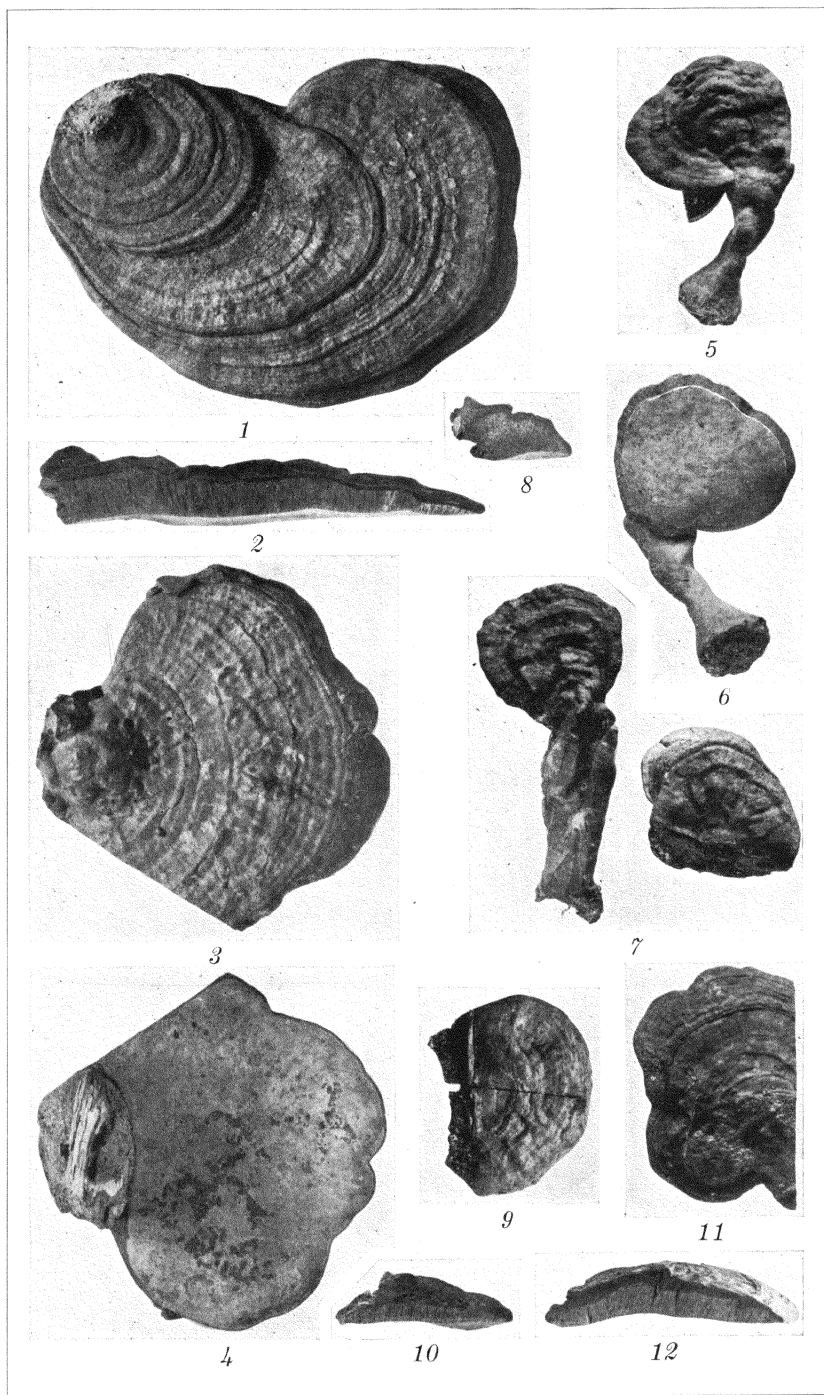


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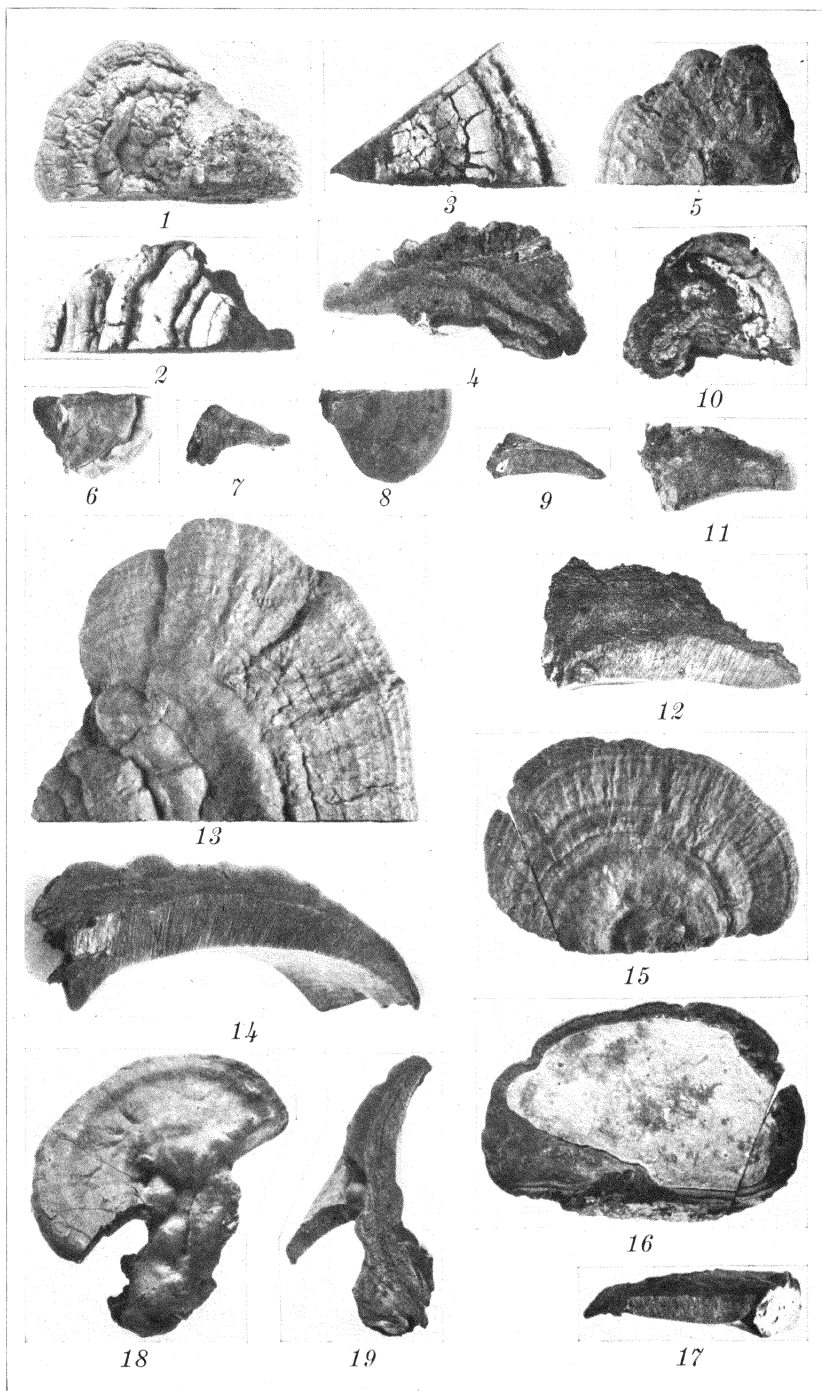


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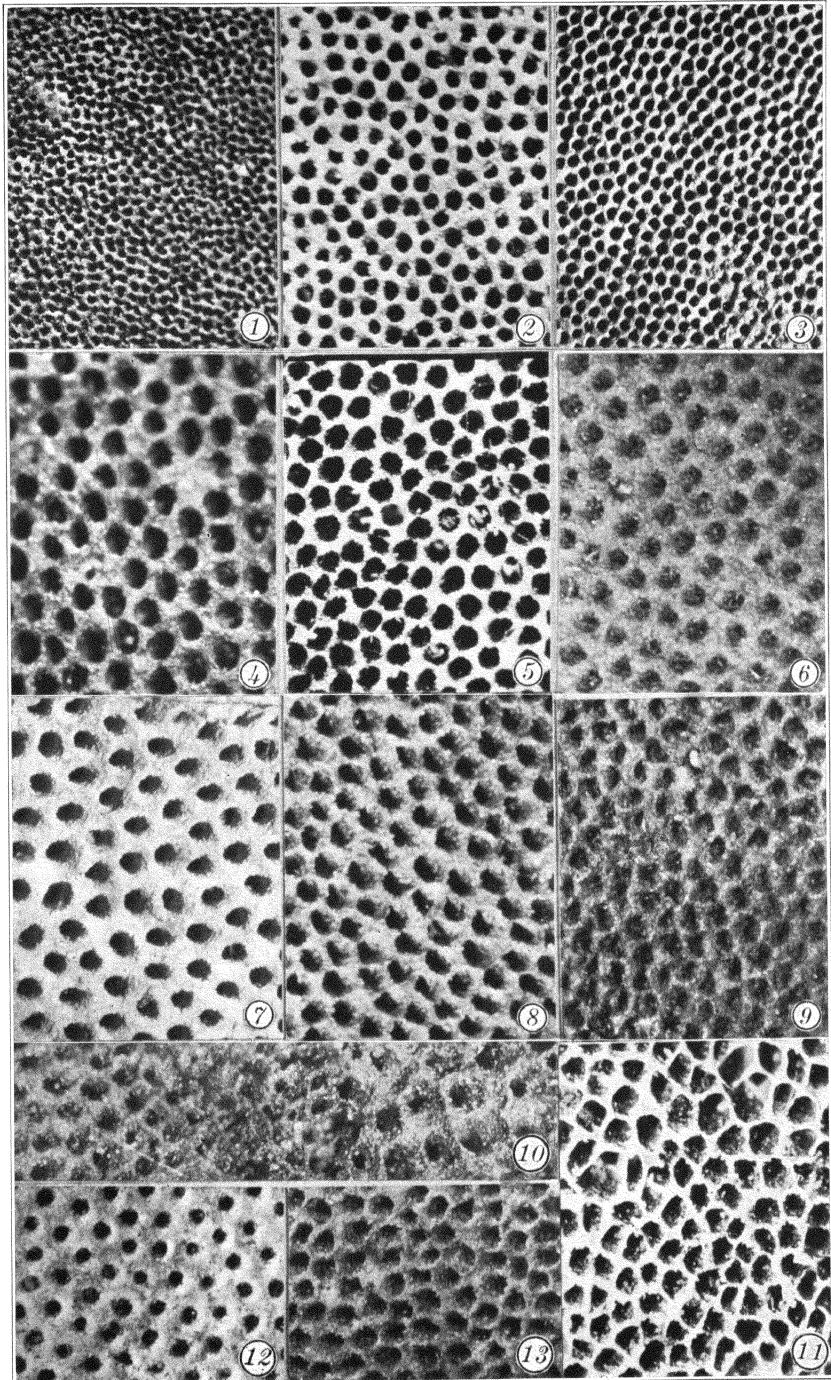


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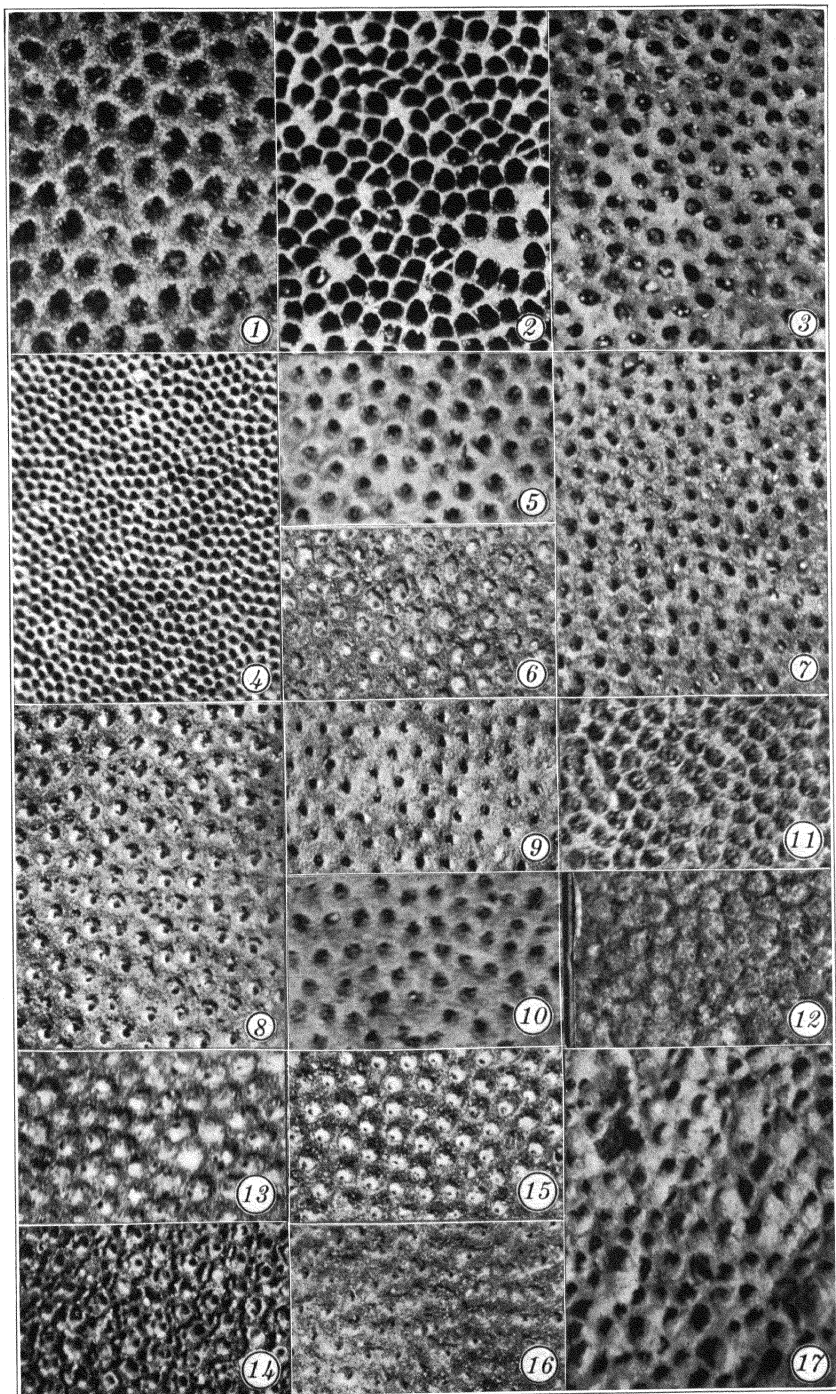


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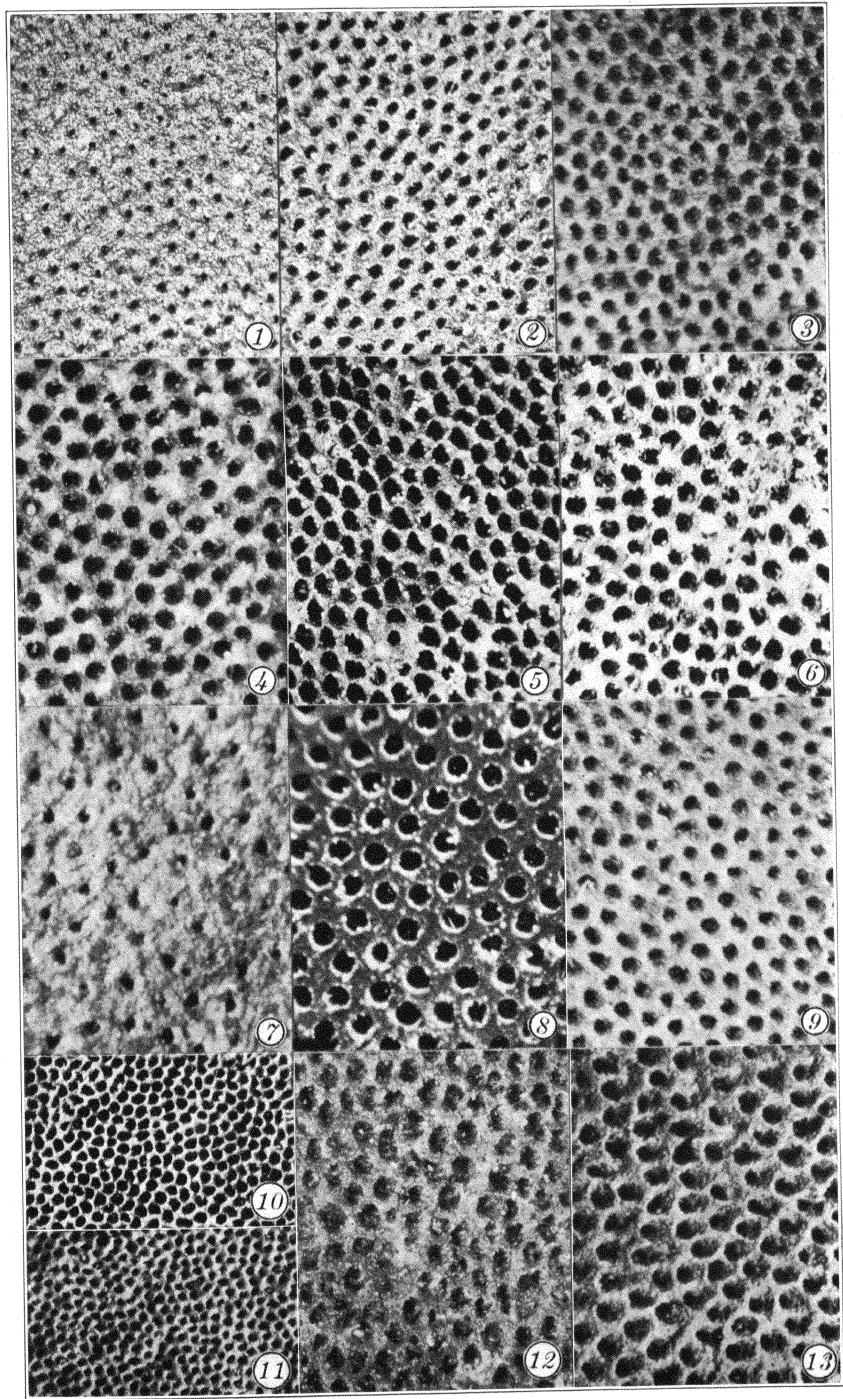


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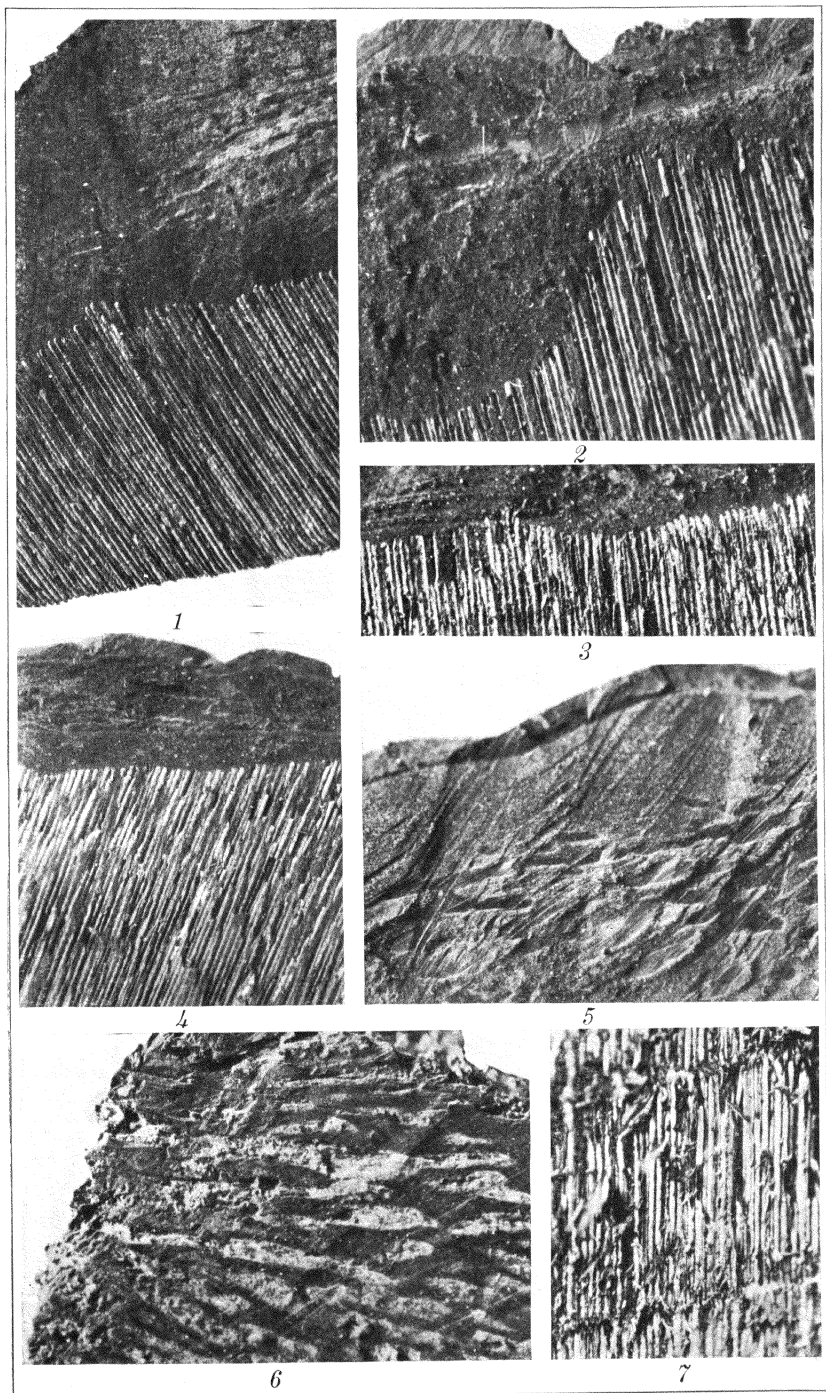
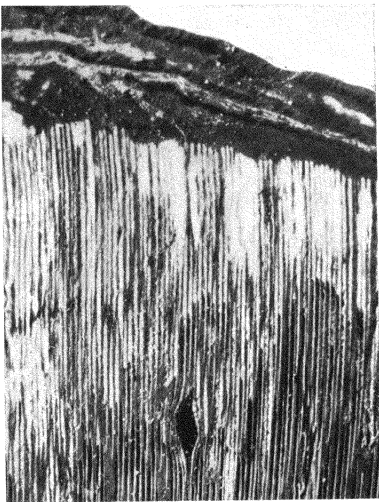
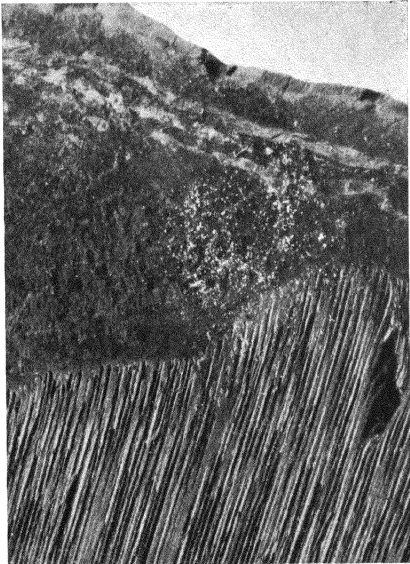


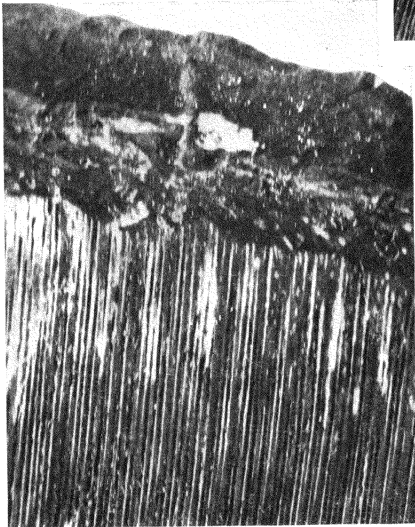
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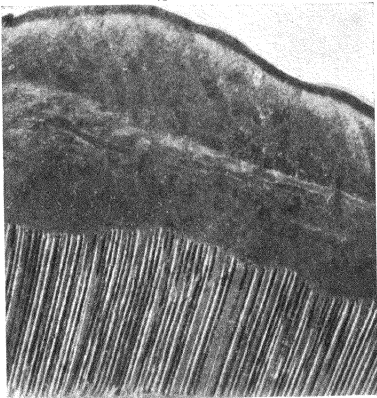
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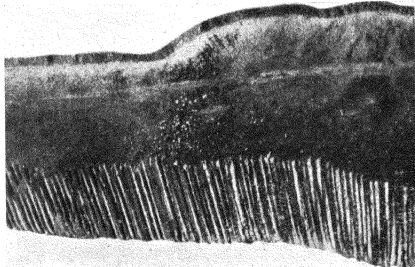
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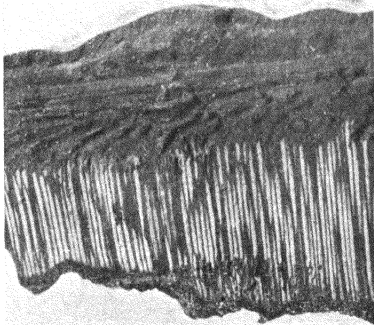
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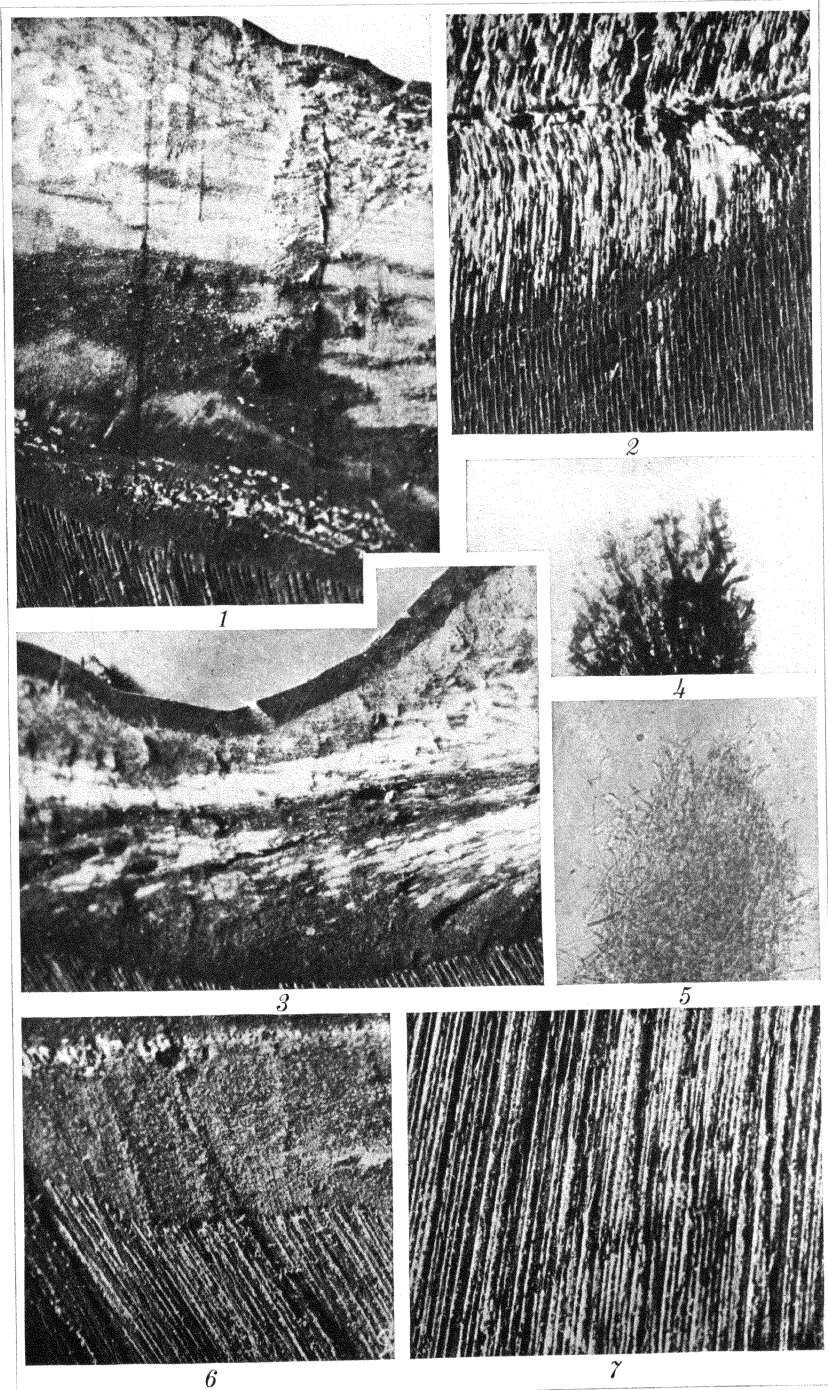
4



5



6



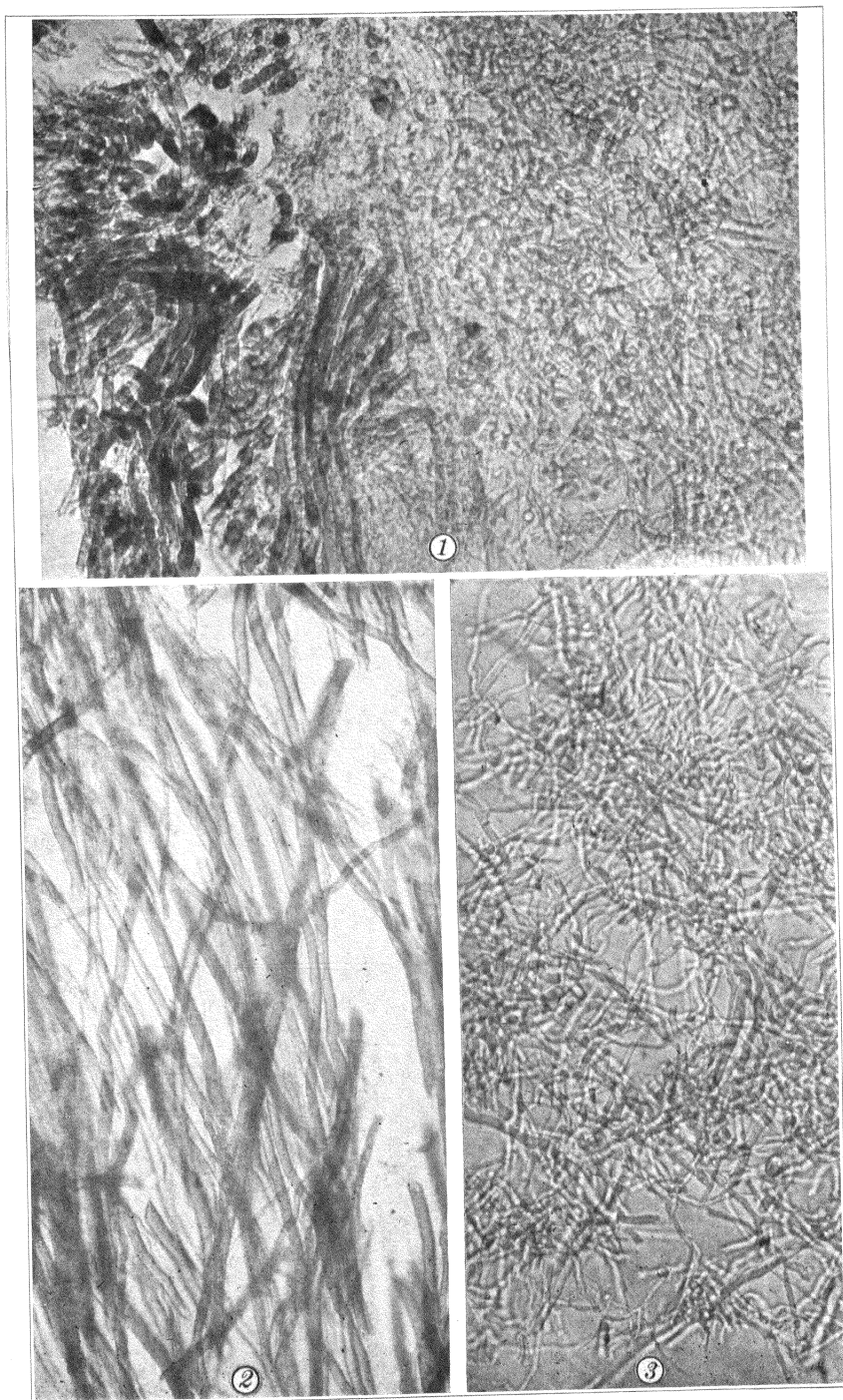
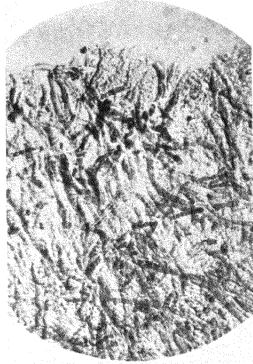


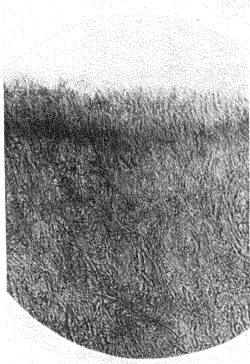
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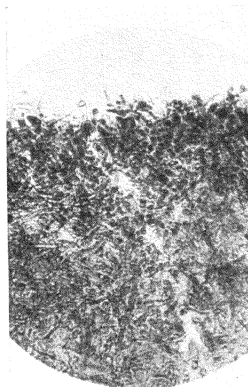
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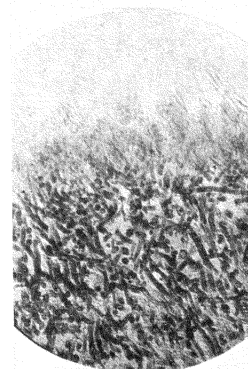
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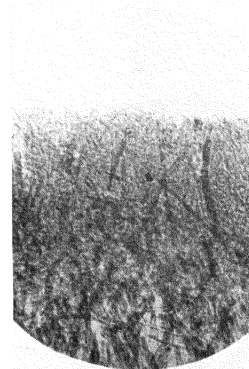
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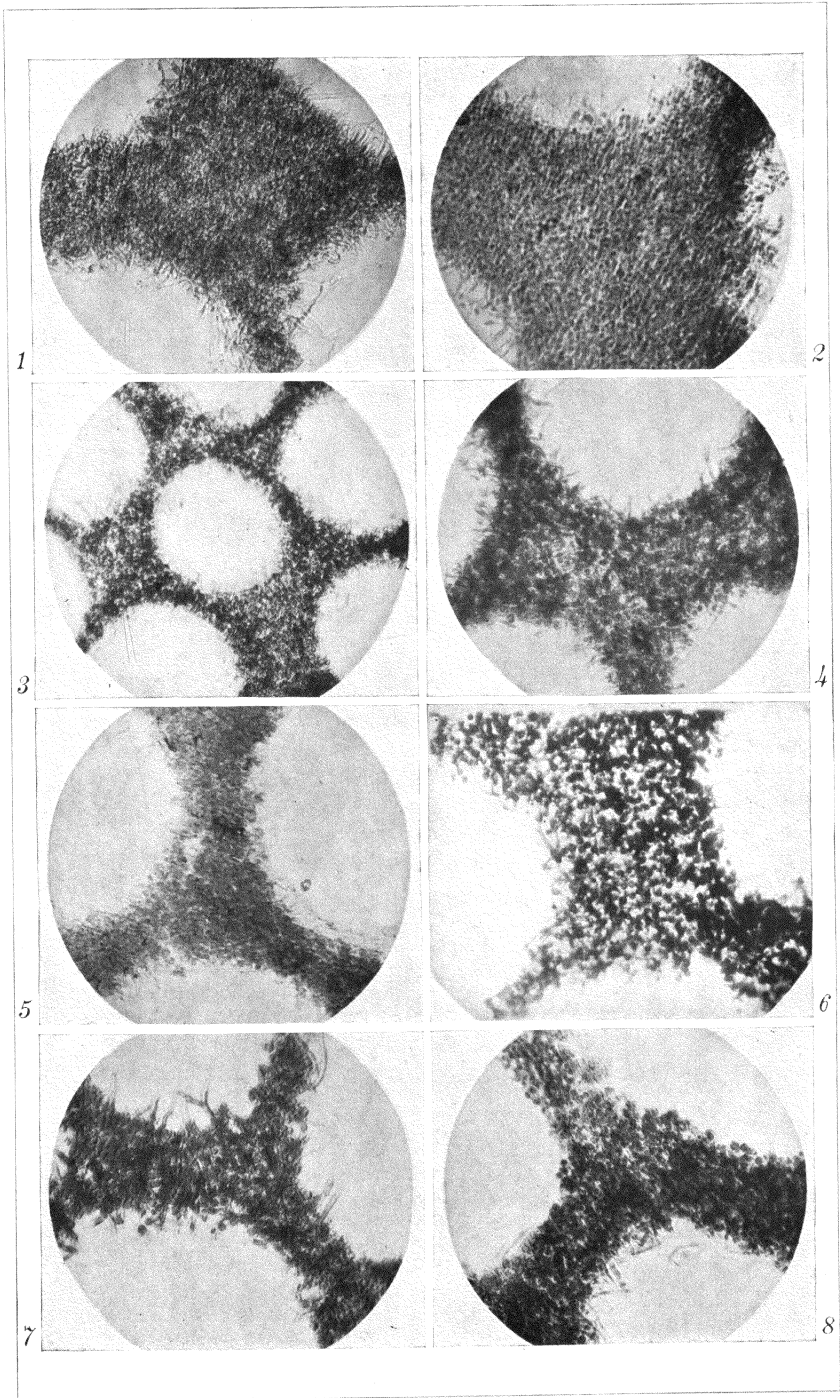
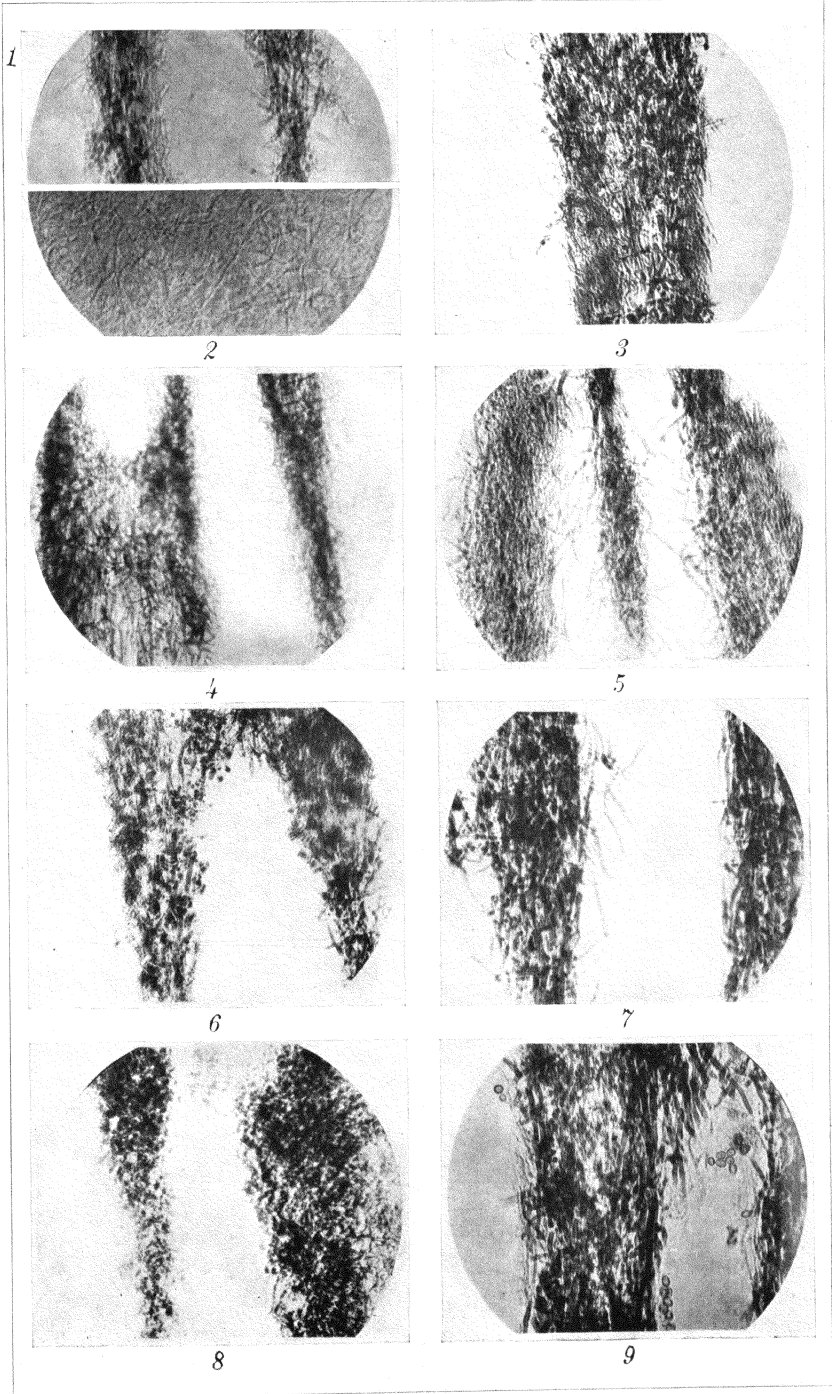


PLATE 30.



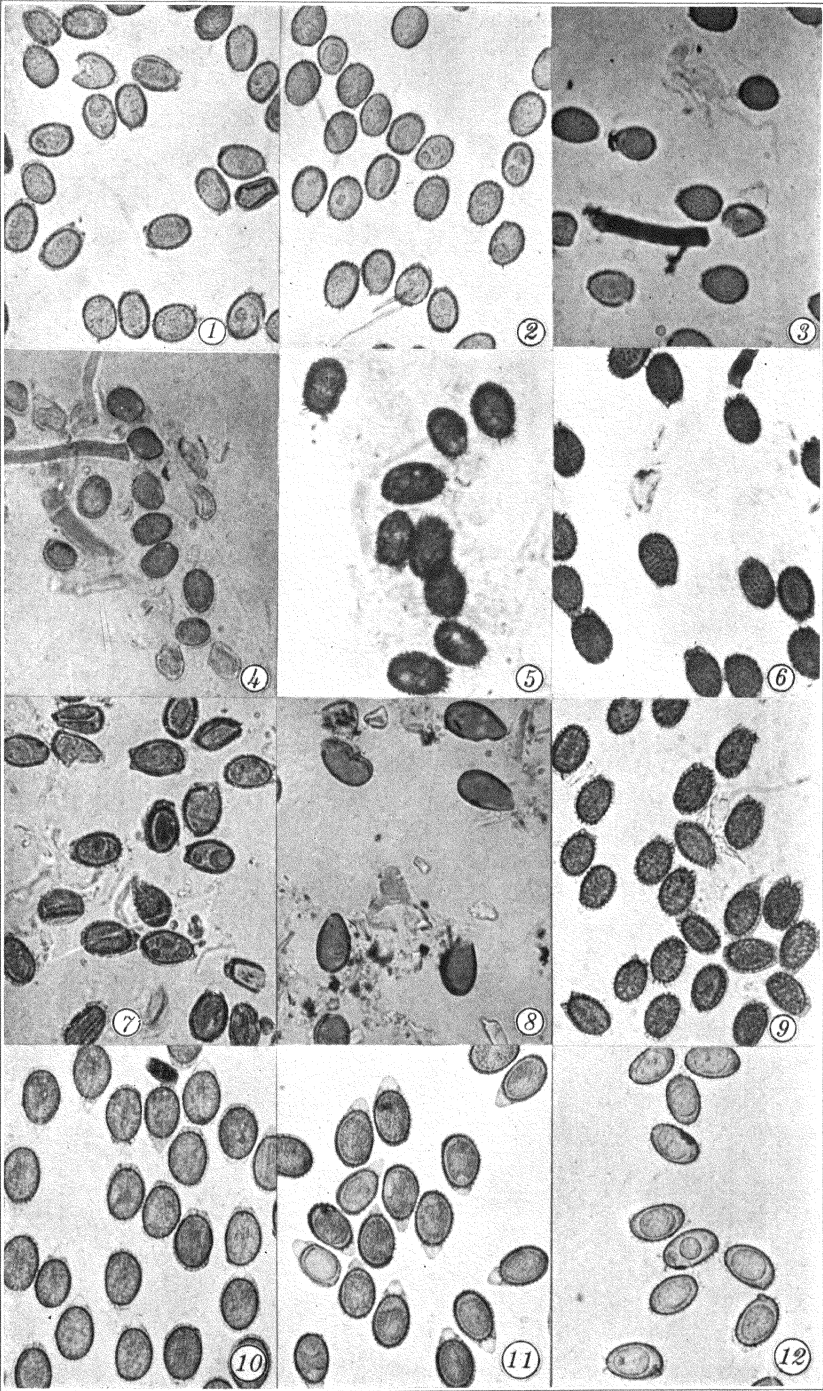


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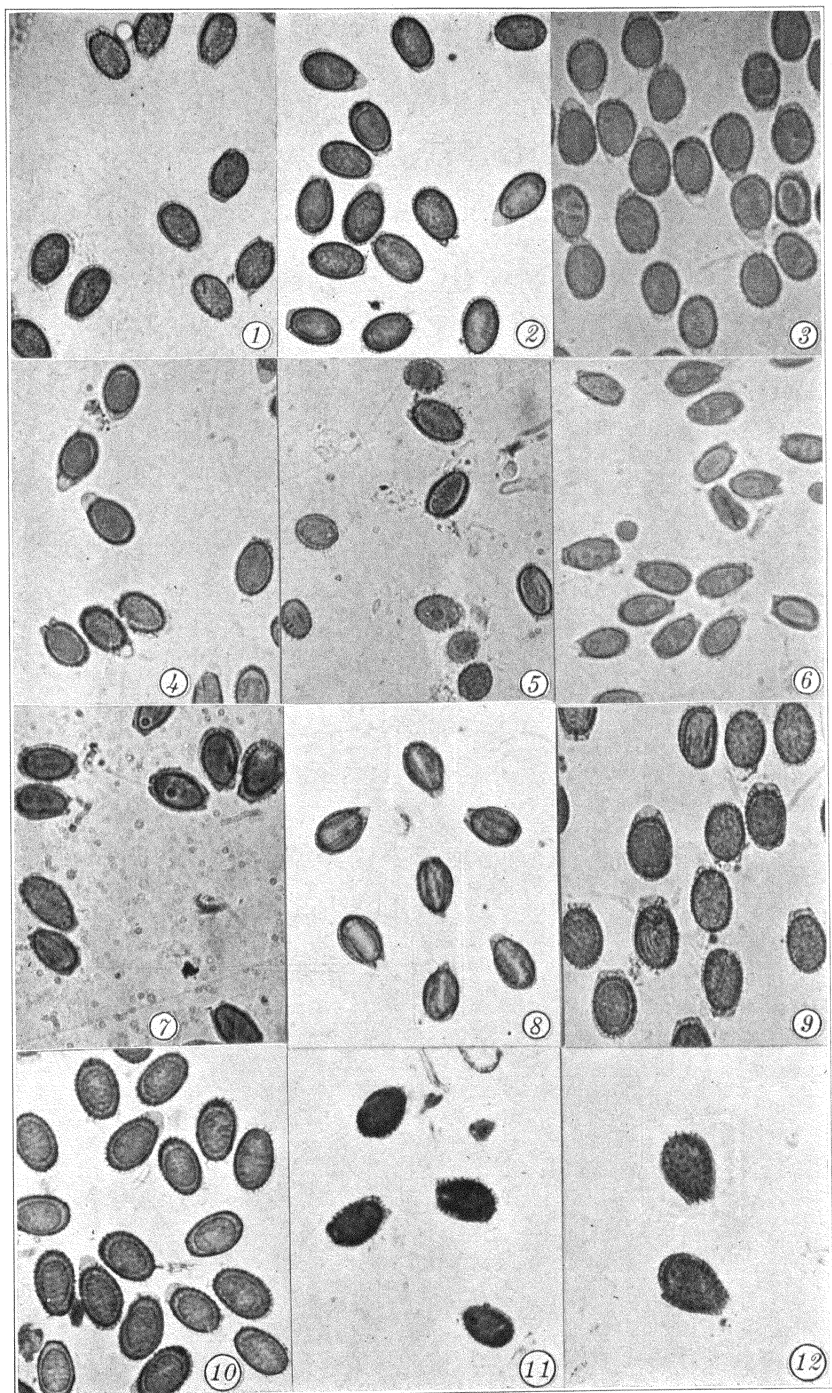


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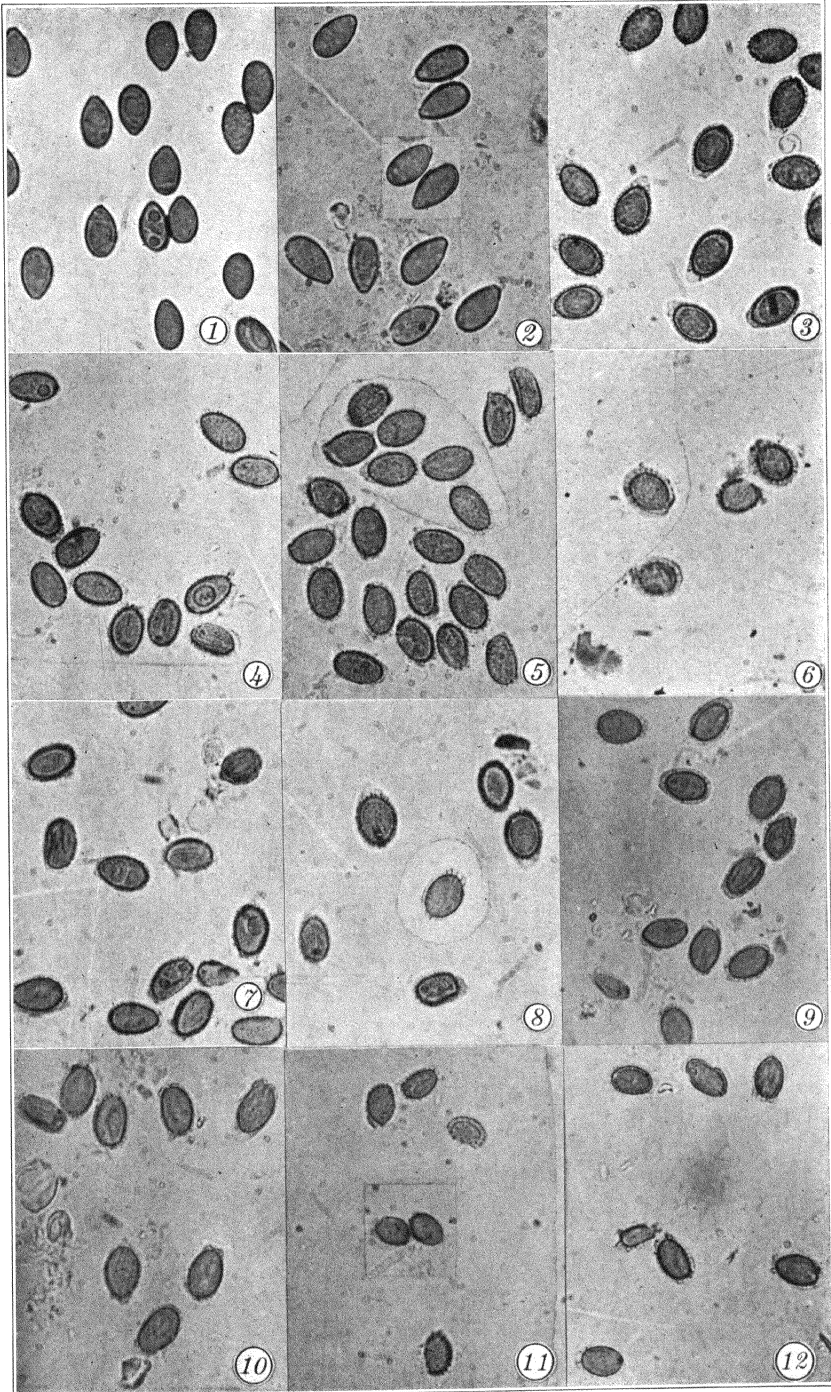


PLATE 34.

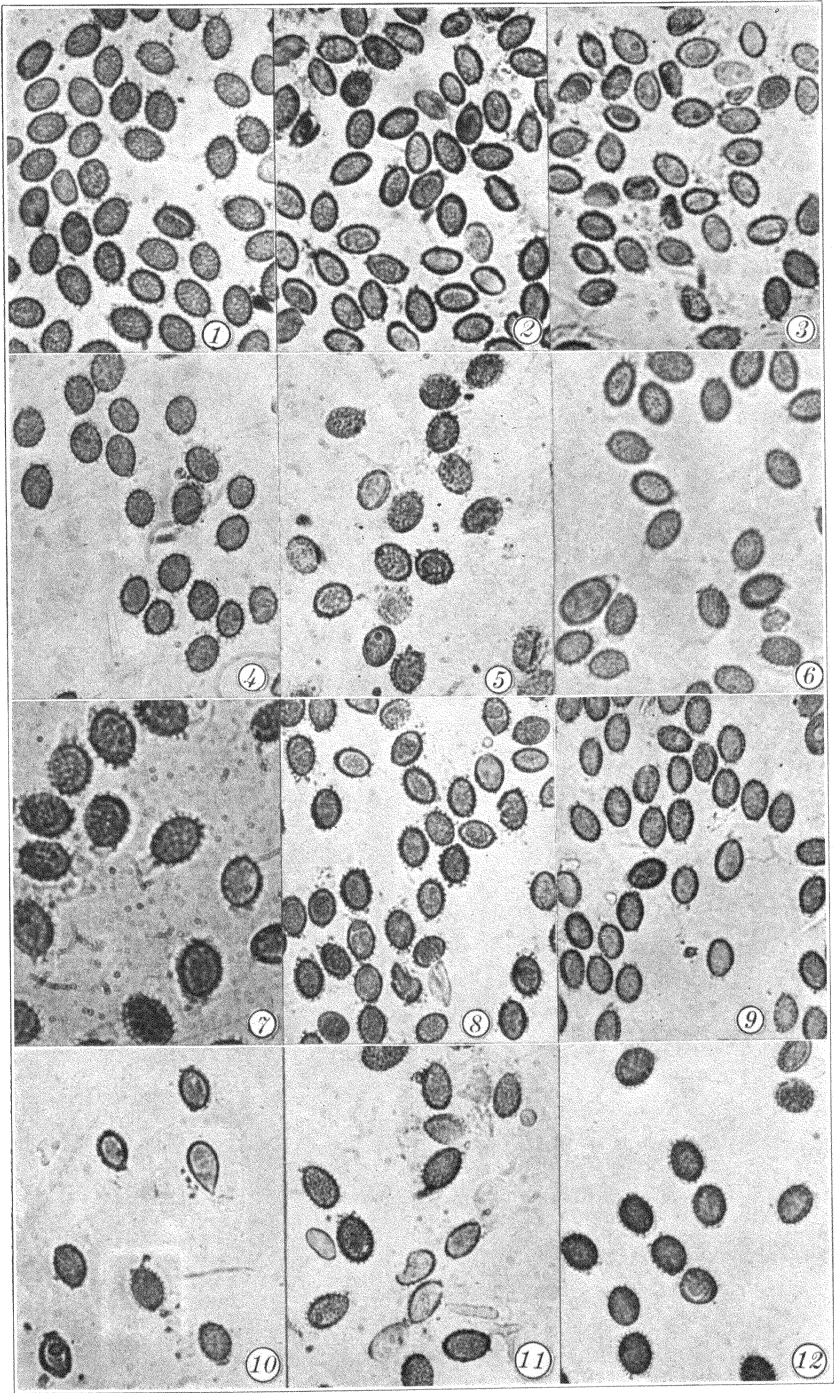


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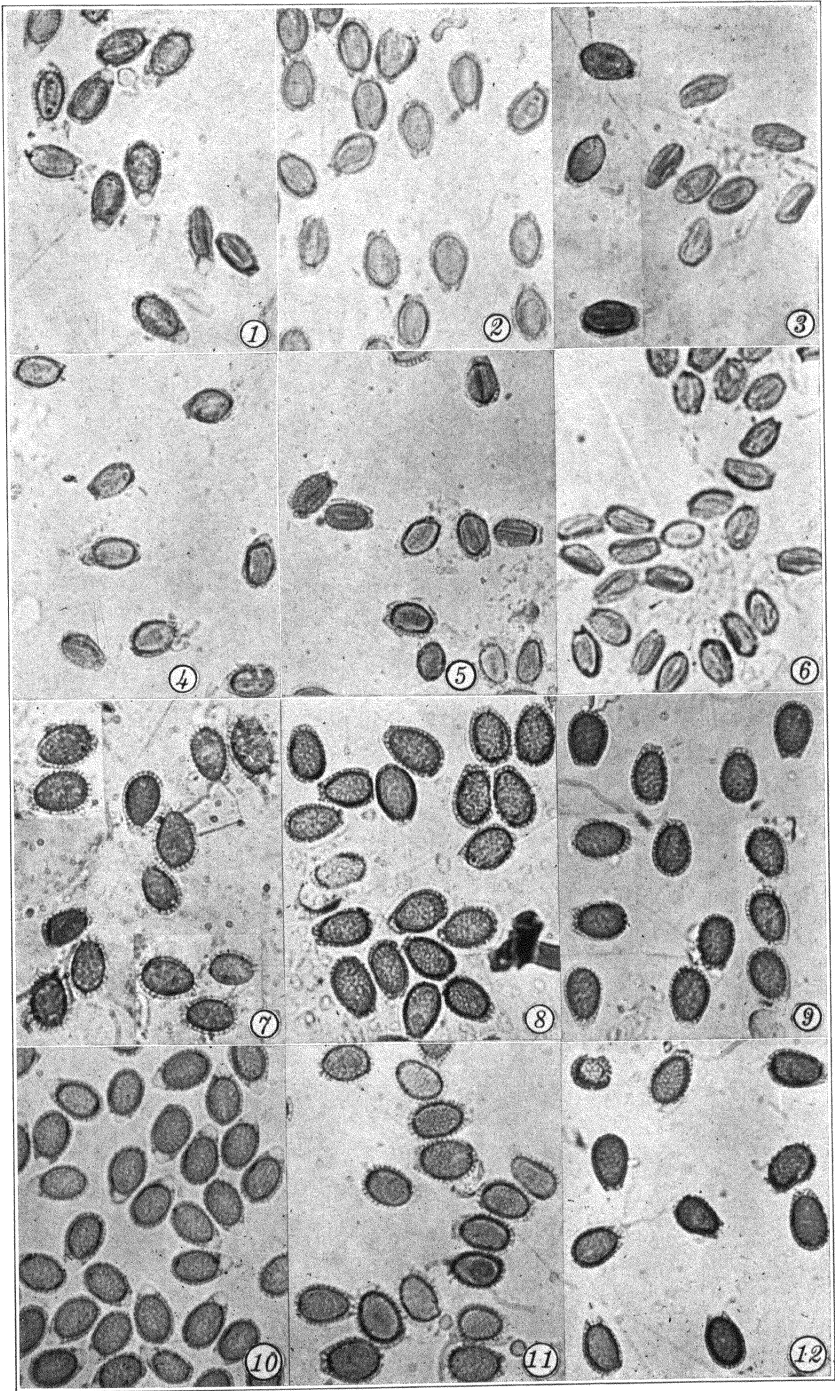


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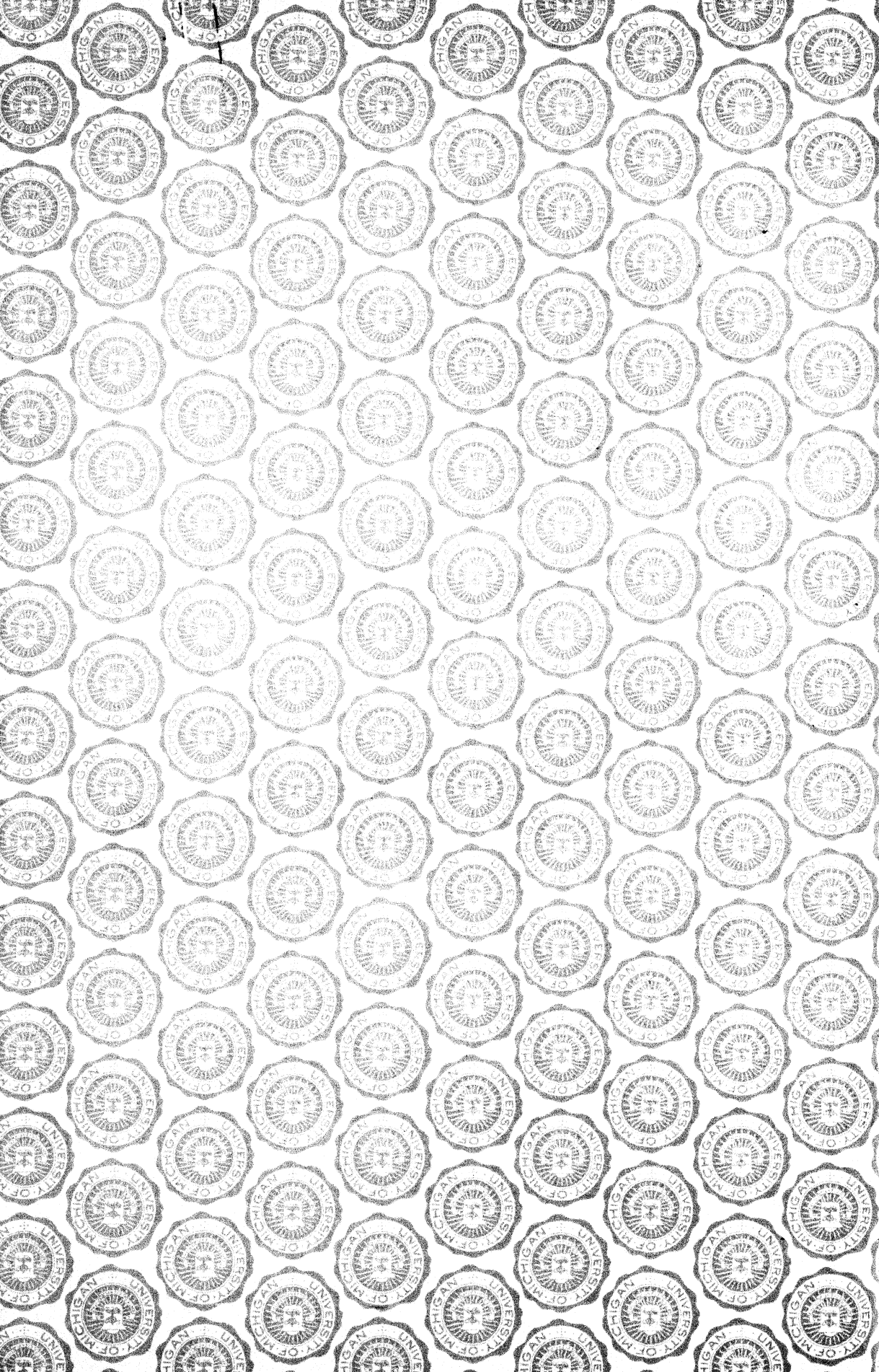
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